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Annual report

SECOND REPORT OF

THE BUREAU OF MINES

1892.

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TO HIS HONOR GEORGE AIREY KIRKPATRICK,
Lieutenant-Governor of Ontario :

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Second Report of the Bureau of Mines.

I have the honor to be, Sir,
Your obedient servant,

A. S. HARDY,
Commissioner of Crown Lands.

DEPARTMENT OF CROWN LANDS,
TORONTO, 15th May, 1893.

SECOND REPORT OF

THE BUREAU OF MINES.

To the Honorable Arthur S. Hardy,
Commissioner of Crown Lands :

Sir,—I am submitting herewith, for presentation to His Honor the Lieutenant-Governor, the Second Report of the Bureau of Mines.

Statistics are given of the areas of mineral lands sold and leased during the calendar year 1892, as well as of the mineral production of the Province for the year ending 31st October. Returns of the latter are made to the Bureau under the provisions of the 60th section of The Mines Act 1892.

Revival of interest in the iron industry suggested the importance of reviewing our past experience with blast furnaces in Ontario, and also of collecting information on the iron ore resources of the Province. Accordingly some space is devoted to these subjects. All statements have been carefully verified, and have been drawn chiefly from official documents and scientific reports and papers.

Separate chapters are also devoted to nickel and its uses, the peat industry, the mining laws of the Province and other subjects, including a very interesting paper by Prof. Coleman on our exhibit of minerals at the World's Fair.

Under the 67th section of The Mines Act 1892 the Inspector of Mines is required to make an annual report of his proceedings to the Director of the Bureau, and his Report accompanies this Report of the Bureau.

I have again to acknowledge the valuable services of Mr. Thomas W. Gibson in the conduct of the affairs of the Bureau. He is a faithful, exact and capable officer.

I have the honor to be, Sir,
Your obedient servant,

ARCHIBALD BLUE,
Director.

Office of the
Bureau of Mines,
Toronto, May 15, 1893.

REPORT OF

THE BUREAU OF MINES.

I.

STATISTICS.

Statistics of mineral production and grants of mineral lands.

The sixtieth section of The Mines Act 1892 requires the owner or agent of every mine to which the Act applies to send to the Bureau of Mines on or before the first of December of each year the statistics of his mine for the year ending on the preceding 31st day of October, according to a form prepared and furnished for this purpose by the Director of the Bureau. The information which the Act requires to be given in this way covers the number of persons employed at the mine above and below ground respectively, the number of such persons over seventeen years of age, the number between fifteen and seventeen years, the average rate of wages earned by workers in each class, and the total amount of wages paid during the year, together with the quantity in statute weight of the mineral dressed and undressed which has been sold, treated or used during the year, and the value or estimated value of it. The Act makes every owner or agent of a mine who fails to comply with this provision of it, or who makes any return which is to his knowledge false in any particular, guilty of an offence for which he is liable to a penalty of fifty dollars, and to a further penalty of five dollars for every day the offence continues after written notice of it has been given. The returns received have not been altogether satisfactory, but doubtless they will improve when the requirements of the Act are better understood and the value of statistics come to be better appreciated by mining men. The statistics of the sale and lease of mining lands have of course been prepared from the records of the Department of Crown Lands. In respect of number of grants for which patents and leases have been issued, as well as of areas conveyed, it will be observed that the districts of Algoma and Nipissing continue to keep the lead. These are the best known mineral regions of the Province, and the most valuable minerals are found within their limits, including gold, silver, nickel and copper. Until recently gold was supposed to be found in workable quantities only in Hastings and in the region in and around Lake-of-the-Woods. But within the last two years promising leads have been discovered in the valleys of the Thessalon and Vermilion rivers in Algoma, and in the vicinity of lake Wahnapitae in Nipissing, and prospecting has been active in those regions, with the result that quite a number of locations have been taken up. Important discoveries of silver, copper and antimony ores have also been reported in the township of Barrie in Frontenac, and of steatite in Grimsthorpe in Hastings, and in both townships prospectors were busily employed last year.

SALE AND LEASE OF MINING LANDS.

Mineral lands sold

Under the new Act mining lands may be acquired by purchase of the fee simple, or by lease for a term of years with right of renewal. The following table shows by districts the areas for which mining patents were issued in 1892, and the amounts paid therefor into the treasury of the Province :

District.	No. of Patents.	Acres.	$
Rainy River....................	27	1,144	3,109.00
Thunder Bay..................	12	2,391	5,598.00
Algoma......................	12	1,500	4,214.50
Nipissing......................	10	779	1,706.50
Elsewhere...	4	386	645.00
Totals....................	65	6,200	15,273.00

No fair comparison can be made with the sales of the previous year, for the reason that in 1891 a large number of patents were issued for which application had been made under the provisions of the old Act. Besides, the preference is now for taking land under the leasing system.

and leased.

The next table shows the number of mining leases issued during the year, the acreage which they covered, and the amount paid into the treasury for the first year's rent charge :

District.	No. of Leases.	Acres.	$
Rainy River..................	9	1,517	1.517.00
Thunder Bay..................	6	990	990.00
Algoma..................	32	4,842½	4,842.51
Nipissing..................	34	3,747⅗	3,749.25
Elsewhere..................	14	2,026	1,215.60
Totals..................	95	13,122½	12,314 36

Popularity of the leasing system.

The leasing clause went into operation on 4th May, 1891. The number of leases issued in that year was 47, embracing an area of 4,998 acres, and the first year's rental paid was $4,886. The average area of locations was 100 acres, while in 1892 it rose to 138 acres, and the number of leases issued was doubled.

A reason for the larger number of leases granted in the latter year is found in the fact that a third of the previous year had passed before the system was brought into effect ; yet this is to be said, that little or no prospecting for minerals in our northern districts can be undertaken before the first of May.

As evidence of the continued growing favor of the system with miners and prospectors, it may be stated that the number of mining leases issued to May 6th of the current year is 54, covering an area of 6,656 acres. The number of patents issued to the same date is 30, covering 2,912 acres. It is probable therefore that the transactions of this year will considerably exceed those of last year.

Payments of the second year's rental fell due last year upon 27 locations, covering 2,461½ acres, to the amount of $603. The rent charge for the second and all subsequent years of the term of a lease is only one-fourth of the rate for the first year.

MINERAL STATISTICS.

Building Stone.

About one hundred quarries were worked during the year for building stone material, chiefly limestone and sandstone. It was not possible to procure returns from all of them, but a careful estimate gives the following statistics of quantity and value for the different classes of material :

Dimension Stone	cu. ft.	2,600,000	$680,000
Heads and Sills	cu. ft.	50,000	26,000
Coursing Stone	sq. yd.	64,000	42,000
Rubble, etc	cu. yd.	730,000	132,000

Making a total value of $880,000. The amount of wages paid to workmen was $730,000,

Natural Rock and Portland Cements.

Much the greater portion of the cement made in Ontario is the product of natural rock, but although the quantity was 7,977 barrels more than in the preceding year the value was $839 less. Portland cement began to be made in 1891, when the output was 2,033 barrels, valued at $5,082. The quantity and value of both classes produced last year are given in the following table :

Natural Rock	bbl.	54,155	$38,580
Portland	"	20,247	47,417

Making a total of 74,402 barrels, valued at $85,997. The amount paid for wages was $53,151.

Lime

The returns received of the quantity of lime burnt last year are not complete. but an estimate places it at 2,600,000 bushels, valued at $350,000, with amount for wages of $120,000.

Brick, Roofing Tile and Terra-cotta.

The following table gives the quantity and value of drain tile, common and pressed brick, roofing tile and terra-cotta made in the Province last year —drain tile and common brick being an estimate based on 161 returns :

Drain Tile	No.	10,000,000	$100,000
Common Brick		175,000,000	980,000
Pressed Brick, plain		20,342,000	198,350
Pressed Brick, fancy		1,323,000	32,253
Roofing Tile		383,000	8,613
Terra-cotta			20,119

The pressed brick works have added largely to the output of 1891, the increase in the number of pieces being 8,431,000, and in value $102,636. One new establishment was put into operation during the year, that of the Thomas Nightingale Pressed Brick Co. at Port Credit. The brick at these works is made from the red shale of the Medina formation. The amount paid for wages during the year by the pressed brick companies was $88,865. The amount of wages paid for making common brick and drain tile was $445,000.

Pottery.

The value of pottery made during the year was $80,000, and the amount of wages paid to workmen in the business was $25,000.

Gypsum.

The gypsum mining industry has been quiet during the year and production was only 72 per cent. of the previous year's. There has been however a considerable increase in the manufacture of alabastine and plastico. Following are the figures for the year :

Gypsum	tons	3,870	$14,100
Alabastine and plastico	"	108	11,800

The amount paid for wages was $10,465.

Phosphate of Lime.

The depression in the phosphate business still continues as a consequence of the low price at which Florida phosphate is sold in the European markets. Only three of the Ontario mines were worked last year, and these to much less than their full capacity. The total quantity raised was 2,381 tons, valued at $23,810. The amount paid for wages, including some development work on other mines, was $9,400.

Salt.

The total quantity of salt of all kinds made during the year ending October 31, as reported to the Bureau by Mr. John Ransford, secretary of the Association, was 43,387 tons, valued at $162,700. It has not been possible to get information in detail, but the following figures are compiled from returns made by the owners of six salt works :

Coarse salt	tons	2,550	$ 9,005
Fine salt	"	8,221	35,461

The cost of wages for this quantity of coarse and fine salts was $9,885. Computed at the same rate the cost of wages for the total make of the year would be about $37,800.

The salt-producing territory of the Province was proven last year to extend as far south as Windsor. A well drilled at the Canadian Pacific Railway station struck a bed of salt 30 feet in thickness at a depth of 1,138 feet. In the township of Orford, in Kent county, a deep well drilled in 1890 for natural gas by Mr. Hiram Walker, of Walkerville, went through a bed of clear white salt 171 feet in thickness, reaching it at a depth of 1,510 ft.

The salt beds of the Province are proven by borings and producing wells to extend under the whole of the counties of Huron, Lambton, Kent and Essex, as well as portions of Middlesex and Bruce, and to cover an area of about 4,000 square miles. Near the borders of the formation the salt thins out to one bed, but in Huron there are usually to be found three distinct beds, separated by shale, whose aggregate thickness is about 90 feet. The greatest known thickness of a deposit is in the southern limit of the field where, as shown by the record of Mr. Walker's boring in Orford, there is one bed 171 feet in thickness.

Mica.

Only one of the mica mines was worked last year and it produced but seven tons, valued at $1,500. The amount of wages paid for labor was $150.

Nickel, Copper and Cobalt.

Four companies carried on mining and smelting operations in the Sudbury district last year. The quantity of ore raised was 72,349 tons, and the quantity smelted was 61,924 tons. Three of the companies have erected bessemerizing plants in connection with their works, employed to enrich the matte ; but only a portion of the matte is treated by this process. The quantity of ordinary matte produced at all the furnaces was 6,278 tons, and of bessemerized matte 1,880 tons. The following table gives the estimated metal contents of these mattes and their values at the works :

Nickel	tons	2,082	$590,902
Copper	"	1,936	232.135
Cobalt	"	8½	3,713

The total value of the metal contents therefore was $826,750, the nickel being calculated at $284 per ton or 14.2 cents per pound, the copper at $120 per ton or 6 cents per pound, and the cobalt at $437 per ton or 21.84 cents per pound.[1] All the ores yielded nickel, the average being 3.36 per cent ;

---

[1] The quantities here given are the estimated contents of the respective refined metals in the mattes, but values are computed on the selling price of mattes at the works and not on the price of the metals after they have been refined in Great Britain, the United States or elsewhere. London quotations for nickel ruled steadily at 42 cents per pound, and New York quotations at 48 to 52 cents, during the latter half of the year,—the higher price in the United States being maintained by the protection of the customs duty. But it would be very misleading to make the value of nickel contents in the matte at Sudbury the same as the value of refined nickel in New York or London.

the ores of three companies yielded copper, the average being 3.19 per cent.; and the ores of one company yielded cobalt, but the average was only .1007 per cent.

Employment of labor.

At the mines there was employed underground an average of 197 men and above ground of 243 men over seventeen years of age, while of boys under seventeen years of age there was employed an average of only 10, all above ground. The average number of men employed at roasting and smelting was 240,—the average of all classes of workers being 690. The mines of one of the companies were worked 310 days, of another 261, of a third 173, and of the fourth 155. The smelting works of one company were in blast 337 days, of a second 290, of a third 67, and of the fourth 32. The aggregate of time of labor in the mines may therefore be computed at 105,890 days, and at roasting and smelting 52,428 days, making a grand total working time of 158,318 days for the 690 employés. The amount of wages paid for labor by the four companies was $339,821, and the average wage per day would therefore be $2.14⅔.

Gold.

Gold mining has been comparatively active during the year, but the work carried on has been mostly of development character. Locations have been worked in the county of Hastings, in the district of East Algoma and in the region of Lake-of-the-Woods. Nine companies have made returns of work done during the year ending 31st October, which show that 3,710 tons of gold ore was mined, the value of which is estimated at $36,900. The number of men employed above ground by those companies was 85, and the number underground 40. The aggregate working time of the men was 12,932 days, and the amount of wages paid was $22,750. The average wage per day would therefore be $1.76.

Mills for treating the ore were being erected at a number of mines, several of which are now in operation. New processes of treating ore are being adopted, and interesting results are looked for this year.

Operations on Lake-of-the Woods.

In the month of December eight properties were in course of active development on Lake-of-the-Woods, the number of mines and laborers employed upon them being 159. Since then reduction mills put up at two of the mines have, it is reported, been treating the ores very successfully. According to accounts published in the Rat Portage newspapers, gold bricks of the value of $1,000 are produced by each plant weekly.

Ophir mine.

The Ophir mine, north of Thessalon, was purchased last year by a Duluth syndicate for $100,000. Several shafts have been sunk on the vein and the show of gold has aroused lively expectations. Treating works are being erected at the Ophir, and it is expected that they will be started in the month of August.

Creighton mine.

The Creighton Gold Mining Co. is developing a location of much promise in the township of Creighton, west of Sudbury. Sixty-three men were employed on the works in February, at which time a shaft of 8 by 9 feet was sunk upon the vein to the depth of 110 feet. Steam drills and hoists were in operation at that time, but air compressors, crushers and other machinery had been ordered and suitable buildings were in course of erection.

Operations in Hastings.

Three mines are being worked in the county of Hastings, one of which has reached a depth of 140 feet. The pyritic ore at this latter mine is being treated in a Crawford mill, and the yield of gold is stated to be very satisfactory. At one of the other mines a new process of treating mispickel ore is going to be tried, which is claimed to give good results in the laboratory.

Silver. Nearly all the silver mines in the Lake Superior district have been idle during the past year, and the work done on five or six locations had for its chief object the opening and proving of veins. This is one of the results of the dèpreciation of silver. An accompanying result is the activity noticed in gold mining, which is also a feature of the industry in the United States and elsewhere.

At one of the mines six men were employed under ground and one above ground for 306 days, and the amount of wages paid for labor was $3,912, or at the rate of $1.84 per day. Ten tons of ore was taken from this mine, the value of which is put down at $732.

Petroleum. The quantity of crude petroleum produced in the Petrolea and Oil Springs fields was 800,000 barrels (28,000,000 imperial gallons), valued at $1,000,000. This is 94,647 barrels less than for the preceding year.

Full details of the industry have not been obtained, as only five refineries have made returns to the Bureau. These refineries treated 11,929,446 gallons in the year, being 42.6 per cent. of the whole yield, the product of which is given in the following table :

Illuminating oil	imp. gal.	4,627,593	$391,628
Lubricating oil	"	1,472,924	58,918
All other oils	"	3,260,912	116.118
Paraffin wax	lb.	276,027	29.922

The amount of wages paid for labor at those five refineries was $40.517. On the same basis, the refined product of the total crude yield of the year would be—

Illuminating oil	imp. gal.,	10,862.894	$919,315
Lubricating oil	"	3,457,570	138.304
All other oils	"	7,654.723	272.577
Paraffin wax	lb.	647,950	70,239

This would give a total value of distilled products of $1,400,435, and at the same rate the amount of wages paid for labor would be $95,110. This does not of course include wages paid to workmen employed in the production and storage of crude petroleum. The total number of employés maintained by the industry is estimated to be about 1,500, and the amount of wages paid for labor of all kinds about $650,000.

Natural Gas. In the Welland gas field forty-nine wells were bored last year, of which thirty-six are gas producers. The total number of producing wells in the district is sixty-five. In Essex two new producing wells were bored last year, and there are now eight in that district. There are about one hundred and fifty miles of pipe laid for the delivery and distribution of gas in both districts, and the value of gas sold to consumers last year was about $160,000. The total amount of wages paid for labor was $55,000, a large proportion of which was for drilling new wells. The returns received from gas companies have not been very satisfactory, especially those made by companies delivering to consumers in Buffalo.

Iron. No iron mining is reported for the year, but several properties were prospected with a view of proving the quantity and value of their ores.

SUMMARY OF MINERAL PRODUCTION.

Product.	Quantity.	Value. $	Wages. $
Dimension stone....cu. ft.	2,600,000	680,000	730.000
Heads and sills .... " "	50,000	26,000	
Coursing stone ....sq yd.	64,000	42,000	
Rubble, etc ....cu. yd.	730,000	132,000	
Natural Rock Cement..bbl	54,155	38.580	53,151
Portland Cement ..... "	20,247	47.417	
Lime ... .bu.	2,600,000	350.000	120,000
Drain Tile............ no.	10,000,000	100.000	445.000
Common brick......... "	175,000,000	980,000	
Pressed brick, plain ... "	20,342,000	198.350	88.865
Pressed brick, fancy... "	1,323,000	32,253	
Roofing tile .... "	383,000	8,613	
Terra-cotta .... "		20,119	
Pottery .... "		80,000	25,000
Gypsum..............tons	3,870	14.100	10,465
Alabastine and plastico "	108	11,880	
Phosphate of lime ..... "	2,381	23,810	9,400
Salt.................. "	43.387	162,700	37,800
Mica .... "	7	1,500	150
Nickel .... "	2,082	590,902	339.821
Copper .... "	1,936	232,135	
Cobalt .... "	8½	3.713	
Gold ore .... "	3,710	36,900	22.750
Silver ore .... "	10	732	3,942
Petroleum ..... imp. gal.	28.000,000		650.000
Illuminating oil " "	10,862,894	919,315	
Lubricating oil " "	3,457,570	138,304	
All other oils .. " "	7.654,723	272,577	
Paraffin wax . ...lb.	647,950	70,239	
Natural gas	....	160,000	55.000
Totals	....	5.374,139	2,591,344

Quantity and value of mineral production, and amount of wages paid fo labor, in 1892.

The total value exceeds the production of last year by $668,466 : but the principal increase is in nickel and copper, in which there is a different basis of values for the two years. The table, it may be explained, gives no

No statistical account of exploratory work.

account of properties upon which exploratory or development work was done during the year. Of these there are a considerable number, especially in the gold and nickel fields. In some cases numerous test pits and shafts have been sunk and several hundred tons of ore raised ; a work which, though not included in statistical returns of quantity, value or wages, may come to have an important effect on the future of mining operations in the Province.

Correspondence.

As was stated in the Report of last year, all transactions relating to sales and leases of mining lands in the surveyed territory of the Province has been assigned to the Bureau of Mines, which of course includes all correspondence in respect of such transactions. The number of letters written by the Bureau last year, including this branch of its work, was 1,417 ; but there was sent out in addition 125 notices to lessees of mining lands *re* rentals, and over 1,000 circulars and schedules for the collection of mineral statistics.

II.

IRON-MAKING IN ONTARIO.

A commonwealth without a blast furnace.

For a country which has had self-government a hundred years, which has a population of more than two millions and a school system of unsurpassed excellence to provide for their education, which possesses rich resources of soil, timber and minerals, including iron ores, which sustains varied industries, and which has large amounts of capital invested and seeking investment, much of it employed in the neighboring States,[1] the Province of Ontario is singular in being almost alone among the great commonwealths of our continent without a blast furnace for the production of metallic iron.

Iron-making has been undertaken at different times and at various places in the Province, but in almost every instance by men without skill or experience, and with only very limited means.

Blast Furnace at Gananoque Falls.

Iron making in Leeds county.

The first blast furnace in Ontario was built by a company in the county of Leeds about the year 1800, at the falls of the Gananoque river. It was an old-fashioned stack, and in connection with it was a forge for the manufacture of bar iron. But the location was too far from ore deposits, having regard to the difficulties and cost of transportation at that early period in the history of the country, and as the ore used was of inferior quality and had to be drawn a considerable distance the venture was abandoned after a trial of two years.[2]

Blast Furnaces in Norfolk County.

Iron making in Charlotteville and Houghton, in Norfolk county.

The next furnace was started about twenty years later, in the township of Charlotteville, county of Norfolk, to smelt the bog iron ore in that district, and it was carried on successfully for a quarter of a century, or until the supply of ore in the locality became exhausted. The smelting of iron appears to have commenced early in 1823, as under date of 15th January in that year the proprietors, Messrs. Joseph VanNorman, Hiram Capron and George Tillson, petitioned the Lieutenant-Governor in Council for leave to take and use ores in the locality, the property of which was in the Crown.

"The petition of the undersigned owners in the concern of VanNorman and Company, being the proprietors of the iron works established on lot No. 16 in front of the first concession of Charlotteville, in the district of London, most humbly sheweth: That your petitioners have their said iron works now at this time heating for the purpose of going immediately into operation:[3]

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[1] The bank statement in the Canada Gazette for the month ending February 8, 1893, showed that there was due to Canadian banks from their own agencies and other banks in foreign countries at that date $21,397,371, while there was due to the latter from the former only $87,710. The balance, $21,309,661, represents the amount of our cash or capital abroad, all or nearly all of which is used for commercial purposes in the United States, but which may be called in whenever it is wanted. At the same date there was due from British banks $1,159,930, and due to them $4,766,619.

[2] Hiel Sliter's Recollections in Leavitt's History of Leeds and Grenville, p. 62.

[3] In a paper furnished by the late Mr. VanNorman, about eight years ago, it is stated that the furnace had been completed and put in blast in 1822, but the statement in the petition is no doubt more authentic. The work of constructing the furnace was begun by John Mason, in 1815, but the inner wall collapsed when only a few tons had been smelted. Mr. Mason died soon after, and the property was acquired by Mr. VanNorman.

That your petitioners trust their said iron works are upon such a scale that they will be found fully efficient for all the purposes required, and therefore pray that your Excellency will be pleased to grant them the privilege of taking and using, from time to time, for and at their said works, such iron ore as may be required from any place or places where the same may abound within the townships of Charlotteville and Middleton."

Iron ores reserved to the Crown.

The patents issued in Upper Canada down to the end of 1823 reserved iron ores to the Crown, except in rare instances; but the petition of the company was no doubt intended to cover the acquisition of ores found upon all lands in the townships named, whether the title to such lands had passed to settlers or was still in the Crown. The report to Council however assumed that the petition only referred to ores on patented lands, and instead of conceding to the company the privilege to take and use them, it was recommended that this privilege should be accorded to the owners of the land.

"It is respectfully submitted that the proprietors of land in Charlotteville and Middleton may be discharged from the restraint in their respective patents as to digging and disposing of iron ore, should it be the opinion of his Majesty's law officers that it may be, and if otherwise that his Majesty's Government may be moved to authorize such discharge."[4]

A second furnace for treating bog ores in the county of Norfolk was built by Mr. VanNorman in the township of Houghton in 1854, with the object of supplying the Great Western Railway with pig iron for the manufacture of car wheels, but the iron proved to be unsuitable and the furnace was blown out.[5]

THE MARMORA IRON WORKS.

Iron making in Hastings county.

In 1820 Charles Hayes began to take steps for making iron at Marmora, in the county of Hastings, and a furnace which was erected there to smelt hard magnetic ores had the ill-fortune to ruin or cripple three or four successive owners in the course of forty years, although for the greater part of that time it was out of blast. Little is known of the early history of this enterprise, but the Departmental and Executive records show that it received some measure of encouragement at the hands of the Government and the Legislature. The first reference to it appears under date of October 26, 1820, when the following Order in Council was adopted:

Land grants by the Government for site of works and fuel reserve.

"Mr. Charles Hayes being heard on a proposition to establish iron works at the Crow river in the township of Marmora, in the Midland district, his Excellency with advice of Council was pleased to grant permission to him to open a road from the Crow lake to Louis Rosebush's in Sydney, as nearly on a straight course as the reserve for roads in the respective townships will admit, and to erect works near to the said lake on Crow river, promising to confirm a location of twelve hundred acres comprehending the site of the works and the buildings inhabited by the labourers by grant of the land so soon as the Executive Government shall be satisfied that works are so complete as to manufacture bar iron and hollow ware; and his Excellency with he advice aforesaid promises to reserve other twelve hundred acres in the neighborhood to supply fuel for the works, and that the grant of land be without the Crown fee, paying only the fee to the patent officers. It is further ordered that he be preferred for one year in the lease of such Crown or Clergy reserves as may be found within this grant and the reserve for fuel.[6]

The tract reserved under the last clause of the Order included the whole of the first and second and part of the third concessions of the township, subsequently changed to the half of the first, second, third and fourth concessions, and covered with Marmora lake an area of 12,000 acres.[7]

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[4] Orders in Council Book No. 6, p. 24.

[5] See Report of Commission on the Mineral Resources of Ontario, pp. 319-20 and 326.

[6] Orders in Council Book No. 5, p. 190.

On 1st October, 1821, Mr. Hayes applied for an extension of time as preferred lessee of this block, stating that he was then deeply engaged in the erection of his works and had "a vast number of men employed."[8]

On 7th June, 1823, he memorialised the Government for issue of the patents for the grant of 1,200 acres located as a site of the works, "having fulfilled the conditions of the Order in Council of 26th October, 1820;" and as the patents were issued in August following it is to be inferred that the furnace as well as the works for the manufacture of bar iron and hollow ware were then completed.[9]

In the same memorial Mr. Hayes petitioned for an enlargement of the fuel reserve from 1,200 to 1,800 acres, and that by act or instrument the grant thereof should be confirmed to him in perpetuity, which request the Council disposed of by the following Order:

"That six hundred acres of land adjacent to the reserve for fuel, for the iron works in Marmora, be added to that reserve, and the whole tract so reserved remain to the use of the iron works so long as they are improved as such without interruption of more than three years."[10]

Subsequently Mr. Hayes obtained permission to dig for and use ore of any description excepting gold and silver on any Crown or Clergy land leased by him.[11]

New reserve of lands for iron ores,

With respect to the reserved tract of 12,000 acres in Marmora, Mr. Hayes discovered that the deposit of ore upon which he relied was outside of its limits, and he submitted to the Government an offer to make a survey of three adjoining townships in which iron ore was likely to be found and to accept a percentage of the lands as his compensation for the work. Accordingly on 30th October, 1821, the following Order in Council was adopted:

"Upon the representation of Mr. Charles Hayes that the bed of ore on which he relied for supply of his contract with his Majesty's Government for iron ballast is discovered to be out of the limits of the reservations made for such purpose, and is likely to be found in the townships of Mora, Ninia or Carlos,[12] and that to obviate any risk of such ore falling into the hands of strangers by the draughts of the surveyors employed to survey the same, and proposing to undertake the survey of these townships at the low rate of four per cent. on condition of being permitted to locate such percentage in a manner to cover the iron ore: his Excellency the Lieutenant-Governor with the advice of the Council is pleased to order and direct that the Surveyor-General do contract with Mr. Hayes on the terms proposed for the survey of the said townships.[13]

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[7] Orders in Council Book No. 5, p. 251, 9th March, 1821. The reserve block is shown on the original map of the township by a shaded border.

[8] Writing to the Governor's secretary on 26th February, 1821, Mr. H. said: "Having had a survey made from the 13th lot in the first concession of Rawdon in a straight line to the rear thereof, and thence to the Crow lake in the township of Marmora, I have now had a road cut throughout which I imagine will be 15 miles in length."

[9] J. H. Bartlett of Montreal states that the iron works were first commenced at Marmora by Mr. Hayes in 1830. "The Manufacture, Consumption and Production of Iron, Steel and Coal in the Dominion of Canada," p. 29. Also Transactions of the American Institute of Mining Engineers, vol XIV, p. 527, by the same writer. But the property had passed into the hands of Hon. Peter McGill before that year as principal creditor of Mr. Hayes, and in 1828 he petitioned the Legislature for a loan of £10,000 to enable him to carry on the works.

[10] Orders in Council Book No. 6, p. 46. An absolute grant of the property was made by the Crown in 1853, upon payment of 10 cents per acre. [11] Ib. p. 47.

[12] Now known respectively as Belmont, Lake and Methuen. Among other curious names of townships in those days in that part of the Province were Alma, Emir, Zeta, Aye, Yea, No, Et, Jus and Norma. O. C. Book No. 5, p. 357.

[13] Orders in Council Book No. 5, p. 358.

located in Belmont.

Business difficulties.

Marmora Foundery Co. incorporated.

In the summer of 1823 the surveys were well nigh completed, and Mr. Hayes solicited the Government for permission to locate in the township of Belmont the whole of his percentage for the three townships. The grounds of this request were, (1) "that the great body of iron ore on which your memorialist relies is within the township of Belmont," and (2) "that in the said township of Belmont is a lake to which from your memorialist's works is a line of water communication, and from which said lake your memorialist has it in contemplation to cut at some future period a canal to connect it with the river Trent, which would be of great importance in transporting iron and other commodities from the said works to the Rice lake, and *vice versa*, and would also be very beneficial to the public."[14] The patents were issued in July, 1824, and covered areas of 8,534 acres in Belmont, including lot 8 in the first concession, upon which is the Big Ore bed or Blairton mine. From this mine most of the ore smelted at the Marmora furnaces was taken. But Mr. Hayes appears to have already become involved in business difficulties, for in September of the same year he made an assignment in trust of a portion of his property, including the land upon which the works were built, to Peter McGill, Anthony Manahan and Robert Hayes. In February, 1825, Messrs. McGill and Manahan surrendered their trust to Charles and Robert Hayes, and in June the property was sold in part to Mr. McGill, who carried on the works for some time in this and the following year. In 1828 Mr. McGill sought, but unsuccessfully, to enlist the aid of the Legislature, having applied for a loan of £10,000, and in October, 1830, he sold the property to Mr. Hetherington. An Act to incorporate the Marmora Foundery Company was procured from the Legislature in the session of 1831, upon the petition of Messrs. Hetherington, McGill and Manahan, with an authorized capital of £50,000, the object as set forth in the preamble being to acquire the Marmora iron works, at that time the property of Mr. Hetherington, to the end that "the said iron works and manufactory should be conducted on an extensive scale, so that his Majesty's subjects in this Province may have a cheap and accessible market for a supply of iron wares independent of any foreign country." A further object as set forth was that "the said Company will be capable of furnishing such ordnance, military and naval stores in the line of their trade as his Majesty's Government may require in this Province in peace or war."[15] This corporation continued to exist at least in name until 1853, when the charter was amended under a new set of directors; but the records of the county registry office show that in 1834 Mr. Hetherington reconveyed the property to Mr. McGill.

Report on a scheme to utilize penitentiary labor in iron making.

The report of the Commissioners appointed in 1837 to ascertain upon what terms the lands and works of the "Marmora Iron Works" might be acquired by the Government, for the purpose of employing the convicts of the penitentiary in the production and manufacture of iron at Marmora, showed that the quantity of land held in fee in the two townships was 10,935 acres, besides the 1,800 acres of fuel reserve.[16] It also appears by this report that the works consisted of two furnaces for smelting ore, a casting house common to both, a forge for the manufacture of bar iron, four coal houses with a capacity of 35,000 bushels each, saw and grist mills, blacksmith's shop, carpenter's shop, store, dwellings, etc., "forming in the view of the Commissioners a more complete and substantial establishment than on its scale of magnitude can be met with in all North America." The value placed by

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[14] Memorial to his Excellency Sir Peregrine Maitland, 14th June, 1823.

[15] An Act to incorporate certain persons under the style and title of the Marmora Foundery Company, passed 16th March, 1831.

[16] Twelve hundred acres of the land in fee was purchased from a private owner (C. A. Hagerman), and the rest was acquired by grant from the Crown. Report of the Commissioners on the Removal of the Penitentiary from Kingston to Marmora, appendix to Journal of the Assembly of Upper Canada, Session 1839, vol. II, pp. 239 and 243.

Mr. McGill on this property in his offer to the Commissioners was £25,000, including the land, and if the statements made by the Commissioners were trustworthy the wonder is that the works should have been allowed to remain idle.

The Big Ore bed in Belmont.

Referring to the supply of ore at the Big Ore bed, they describe it as a mountain on the shore of Crow lake entirely composed of iron ore. "Inasmuch as the Commissioners had never before a conception of such a quantity of ore in one mass in such a position, their surprise was exceeding, for the first consideration that must be given to this locality is that it is inexhaustible for all the purposes which may be forever required for this Province." They also found that with a boat of fifty tons navigated by four men one hundred and fifty tons of ore from the head of the lake might easily be brought to the works in two days, so readily was it quarried and put on board there.[17] The extent of this ore body is better known now, but the impression produced upon the minds of the Commissioners was doubtless an effect of novelty.

A furnace record.

As to the profits of the business, the report gave the following figures of actual cost and production as shown by the record of the new furnace for a campaign of five months:[18]

STATEMENT OF THE EXPENSES OF WAGES INCURRED IN THE WORKING OF THE NEW FURNACE, BLAST COMMENCING ON THE 15TH DAY OF DECEMBER, 1825, AND ENDING ON THE 15TH DAY OF MAY, 1826

	£.	s.	d.
To the founder, John Jones, 152 days at 15s. per diem	114	0	0
To 2 firemen, Campbell & Dyer, 152 days at 6s. 3d. each per diem	95	0	0
To the ballast moulder, Seagriff, 152 days at 5s. per diem	38	0	0
To 2 top-men or tillers, 1 banksman and 1 ore-burner at $24 per month each	120	0	0
To 1 gutter-man at $20 per month	25	0	0
To the carpenter who attended the bellows, 1s. per day extra wages, 152 days and $12 allowed for the blast	10	12	0
To the average labor of 2 men each day employed in making log-heaps, filling ore, raising clay and sand, etc., 152 days at 3s. 3d. per diem	24	14	0
To the expense of 600 bushels of coals each day for 152 days, at 21s. 6d. per hundred	980	8	0
To the average quantity of ore, 4 tons per diem, for 152 days, at 5s. per ton	152	0	0
To allowance for candles, oil, tar, etc., for the casting-house, moulding, and use of bellows, at 1s. per diem for 152 days.	7	12	0
Total expense	1,567	6	0

During the blast she cast as follows, viz:

In December	90½ pigs
January	316 do
February	341 do
March	483 do
April	466 do
May	218 do
Total	1,914½ pigs

Say 1,914½ pigs, equal to 273½ tons, which at £15 10s. Currency net at Kingston (allowing 40s. per ton, take the actual expense of transportation thither), will amount to £4,239 5s., showing the gain by the furnace in the five months' blast as follows, viz:

	£.	s.	d.
The proceeds at Kingston	4,239	5	0
Deduct the amount of expenses as set forth	1,567	6	0
Profit she has actually made	2,671	19	0

In this statement no charge is made for interest upon the capital invested. At Mr. McGill's valuation of £25,000 this would amount at 6 per cent. to

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[17] Report, p. 238.

[18] Report p. 245.

£625 for the five months, which would still show a profit made by running the furnace for that time of more than £2,000 The allowance for wages, it will be noticed, is fairly liberal even at present rates ; but 4⅓ cents per bushel for charcoal and $1 per ton for ore are low figures. On the other hand, $62.50 per ton for pig iron is nearly four times the price of charcoal pig at the present time in Michigan.

Importance of the works.

Commenting upon the statement and other facts elicited by their enquiry the Commissioners observed in their report that they "serve to show the importance of the works, if even conducted upon the moderate scale of operations upon which they have hitherto been managed, by which it appears that by the operations of only one furnace in blast for the year, and the forges making but three tons of bar iron per week, an annual profit of £13,037 18s. 6d. was estimated to accrue, after paying all the contingencies chargeable on the operations producing it, and valuing the produce at a net price under the market rates, deducting charges of transport and sale ; a profit (independent of the advantage to the country of having even so much of the supply of so necessary an article of consumption as iron furnished within ourselves) which would cover the first heavy outlay of building and otherwise preparing for the safe-keeping and accommodation of the convicts in the event of transferring them to the establishment. But the Commissioners cannot contemplate the probability of confining the operations of an establishment like this, and of one of the manufactures in the rank of utility most essential to mankind, with the unequalled privileges and advantages which the works possess, to be confined to the making of a few hundred tons of castings and bar iron every year—while the Province is annually disbursing hundreds of thousands of pounds for that commodity from abroad which could be profitably produced at home of a far superior quality and at a diminished price. Independent especially of the great importance which the establishment would prove to the Queen's Government in the time of war, as a resource to supply all the ordnance and munitions of war in their line, a resource contemplated with approbation by the Home Government when to foster the iron works into existence they gave a contract to Mr. Hayes for the delivery of pig iron ballast into the naval yard at Kingston at a full remunerating price, to the extent of £13,000 sterling."[19]

Estimates of value of the estate,

That the Commissioners showed only the bright side of the shield is apparent when the estimates of value of the estate and profits earned by the works are examined. The following statements possesses historic as well as economic interest :"[20]

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[19] Report, p. 239.—Reference to this contract is made in the Order in Council of 30th October, 1821, (p. 15 ante). In those days pig iron was largely used as ballast for ships of war, for which purpose it was cast into lengths of about three feet, with a hole at each end through which a cable was slipped to make a connected but easily shifted weight. This explains the item ot £38 for wages paid to the ballast moulder in the foregoing statement. Since the era of steam navigation coal is the principal article used for ballast in war ships.

[20] Report, p. 242.—The following detailed description of the works is given in the report of the Commissioners : "The works, of which a ground view with references is herewith presented, consists of two furnaces for smelting iron ore, connected by a casting house common to both, with the wheel house and bellows house attached to each, having in the same file of building several capacious rooms and lofts, usefully occupied in the purposes of a foundry—the whole forming one solid mass of building of limestone, constructed on the face of a bank of the same material, forty feet high to the level of the bank ; on this bank (an area of five acres of which is enclosed with a dry wall) three substantially framed coal houses are built, sufficient to contain each 35,000 bushels of coal ; another portion of the same bank has hitherto been occupied as a coal and ore bank, where the ore has been usually roasted on log heaps, to free it by that process from the intermixed sulphur, and upon the unoccupied part of it much if not all the charcoal required for the uses of the furnaces could be most profitably made, as will be hereafter shown. The furnaces, as conducted formerly by private enterprise, were found capable of making four tons of iron daily, on the average ; statements in which respect they are enabled to submit by politeness of the Honourable Peter McGill, the proprietor. In connection with the furnaces is a large and substantial stone building, containing two trip

ESTIMATE OF THE PRESENT VALUE OF THE ESTATE IN THE MARMORA IRON WORKS.

	£.	s.	d.
The new furnace, being the largest, is considered to have cost in its construction, with the two apartments attached, and the complete top-house, bellows-house and wheel-house	1,000	0	0
The bellows, bellows gear, wheel and shaft cost	250	0	0
The castings-house for both furnaces cost	400	0	0
The old furnace, wheel, bellows, bellows-house, wheel-house, top-house and sparking-room, in the ratio of the other furnace	1,000	0	0
The forge-house, with four fires, two trip-hammers, containing four sets bellows impelled by water from four different wheels, and the two hammers—two different wheels—original cost upwards of £2,500 ; present value at the lowest estimate	2,000	0	0
Carpenter's shop, complete	150	0	0
Four coal houses, at £30 each	120	0	0
Grist mill, one run of stone, complete, and smut machine	500	0	0
Saw mill, two pit and one circular saws, complete	300	0	0
Bark mill and tannery	200	0	0
Dwelling house	300	0	0
Stone boarding house	200	0	0
New store and office	300	0	0
Rake house, old office and old store	50	0	0
The clerk's house	180	0	0
Twelve dwelling houses for men, at £60	720	0	0
Barn, stable, root house, cattle shed, ash house as a dry house, ashes, etc	150	0	0
Water lot in Belleville, value	100	0	0
14,000 acres of land, at 20s. per acre	14,000	0	0
Utensils, etc., and lower store, patterns, etc., fire engine	300	0	0
Length of flume and canal	750	0	0
The two dams and breakwater as they now stand	500	0	0
Stock of ore	300	0	0
	£23,770	0	0

and profits of the business.

The quantity of land belonging to the works was only 12,735 acres, not 14,000, and the total estimate for the property should therefore be reduced by £1,265, leaving it £22,505 or nearly £2,500 less than the price set upon it by the owner. With plant and property of this value the Commissioners made the following estimate of profits on a year's business based upon the

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hammers and four forge fires, for the purpose of making bar iron, with two wheels which trip the hammers, and four wheels that propel the bellows, one to each fire. This factory, put in active and kept in constant operation, is capable of making five tons of bar iron per week of all sizes and descriptions, and is now in a state requiring but moderate repair to fit it for immediate use.

"On the forge bank, a clear area of two acres, is another well built coal house, of equal size with those belonging to the furnaces ; attached to the forges is a convenient carpenter's shop, sufficiently capacious to accommodate five workmen, with a lathe and grinding stone impelled by water, the upper loft of this shop forming a convenient and spacious moulding and framing room for moulding, planning and putting together large patterns and moulds ; opposite and at a convenient distance between the furnaces and forges stands the general pattern store, and occupied besides as a casting and bar iron sale and deposit store, a good frame building, built on a solid foundation on the water's edge.

"Next on the falls occur in their order the blacksmith's forge, suited for two smiths, with benches and utensils complete ; a bakery, the baker and miller's house, adjacent to a respectable grist mill, the under story of stone, the upper handsome, substantial, well-finished frame-work, one run of stone and a smut machine ; contiguous to which is a superior saw-mill, newly built, with two pit saws and a circular saw ; and near thereto on a small-island, a situation admirably adapted for the purpose, is a substantial two-story building—under story stone, the upper story frame work, fitted into a most complete tannery, with vats, utensils and bark mill complete ; added to these are several very valuable dwelling houses, some of them stone—a stone store and offices—a barn, barnyard and sheds, forming in the view of the Commissioners a more complete and substantial establishment than on its scale of magnitude can be met with in all North America." pp. 236-7.

working of the new furnace for a campaign of five months, allowing each furnace to continue in blast oniy six months of the year.[21]

	£.	s.	d.
Semi annual profits of the new furnace	4,029	16	10
do do old furnace	2,442	10	10
Profits on sales of merchandise, provisions, etc., per annum..	1,050	0	0
Profits on 156 tons bar iron	1,423	10	0
And that valued upon the farm........................	200	0	0
Total yearly revenue.........	9,145	17	8

The first of these items is calculated upon 328 and the second upon 225 tons of pig iron converted into castings, at £20 per ton. But the particulars are not very satisfactory. They afford good ground for criticism, and it may be presumed that the Government of the day was not dazzled with a prospect of making 36 per cent. profit on an investment of $100,000, or even 40 per cent. on $95,000, the Commissioners' valuation of the property and works.[22]

One member of the Commission (Isaac Fraser of Ernestown), who presented a minority report, appears, while persuaded of the value of the plant and the importance of the industry, to have seriously doubted the wisdom of the Government's engaging in the business.

Reasons against Government undertaking the business with convict labor.

"Without offering an opinion on the present value of the establishment," he stated, "the undersigned is fully persuaded that it possesses very great facilities and advantages for the extensive manufacture of iron, and that a more eligible situation for that purpose cannot be selected in this Province; but whether the manufacturing of iron on the public account and at the public cost, in preference to leaving that, as well as all other branches of industry, open to the free competition, skill, enterprise and capital of such individuals or companies as may wish to engage in the same, will be for the Legislature in its wisdom to decide. The principal object in transferring the penitentiary from Kingston to Marmora would seem to be the employment of convict labour, so as not to interfere with the pursuits of the honest mechanics of the Province; but if this object can be equally well attained at the present establishment, it is evident that the loss of the large amount already expended on it will be avoided, and the necessity of a further large outlay would be prevented."[23]

These views, and the representations of the warden of the penitentiary on the difficulty of maintaining discipline over the convicts, the necessity which would arise for employment of extra keepers to prevent their escape, the unsuitability of men with constitutions impaired and destroyed by intemperance and other excesses for hard labor, and the greater cost of maintaining a penal institution, whose inmates would be thus employed in an isolated location,[24] appear to have convinced the Government that the project could not be carried out.

VanNorman's venture at Marmora.

Nothing further seems to have been done with the Marmora works until 1847, when the property was purchased by Joseph VanNorman, of the Charlotteville furnace, for $21,000. Mr. VanNorman spent a large sum in repairing and improving the works, and began making iron in the summer of the following year. But he had no skill in treating hard magnetic ores, and all his efforts were attended with disappointment and loss. Shipments of product were made at first over a rough waggon road to Belleville, a distance of thirty-two miles ; but by cutting nine miles of road from the mine at Crow lake to Healy's falls on the Trent river a new land and water route was obtained whereby, although bulk was broken three times, pig iron could be delivered at Cobourg more easily and at less cost than at Belleville. Sales were made for a short time at $30 to $35 per ton ; but after the construction of the St. Lawrence canals British iron could be brought up the country and sold at a much lower rate, and Mr. VanNorman was compelled to close his works with the loss of everything.

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[21] Report, p. 247.

[22] One of the Commissioners who signed this report was Anthony Manahan, a charter director of the Marmora Foundery Company. George N. Ridley was the other.

[23] Report, p. 249. [24] Ib. p. 255.

A new company organized, and a large fuel reserve acquired.

In July, 1849, Mr. McGill conveyed the lands at Marmora which he had acquired from Mr. Hetherington in 1834 to the Marmora Foundery Company, and in 1853 this company was reconstructed under an amending charter and a capital of £80,000 stg. "to carry on extensively the manufacture of iron and steel." Among the new directors were A. T. Galt, Peter McGill, Alexander Simpson, William C. Evans and James B. Greenshields of Montreal ; William Rhodes and Edward Burstall of Quebec ; Robert Gillespie of London, and W. A. Matthews, mayor of Sheffield, Eng., and it was provided that the Act should not go into operation until £30,000 was paid in. Little is known of the affairs of this company until 1856, when it applied to purchase at a reduced price 20,000 acres of land as a fuel reserve. The matter was brought to the attention of the Legislature in the session of 1857, and the following resolution was adopted :

"That it is expedient to encourage the manufacture and production of iron in this Province, and for that purpose to allow the Marmora Iron Company to purchase for a fuel reserve waste lands of the Crown in the townships of Marmora, Belmont and Lake not exceeding 20,000 acres at the price of not less than one shilling and sixpence currency per acre."[25]

Amalgamation with the Cobourg and Peterborough Railway Co.

Mining operations resumed.

The property sold by order of the court.

An Order in Council of 20th October, 1857, authorised the Commissioner of Crown Lands to carry out the sale to the company at thirty cents per acre, although the price of public lands in the Province at that time, as fixed by regulation, was eighty cents per acre. Patents for 15,000 acres of this purchase were issued in 1863, and for 4,800 acres in 1872 ; but in the meantime the company had become amalgamated with the Cobourg and Peterborough Railway Company, under the title of the Cobourg, Peterborough and Marmora Railway and Mining Company. The deed of amalgamation between the two companies was signed December 28, 1866, and in the following year mining operations were resumed at Big Ore bed[26] and shipments of ore began to be made to Cleveland and Pittsburgh *via* Cobourg. A section of railway, eight miles long, was built from the mine to the Narrows on the Trent river, whence the ore was taken by boat to Harwood station on Rice lake, and again put on cars for Cobourg. The shipping season did not last more than four months of a year, owing to difficulties of river navigation, and during this period about 100 tons per day were moved from the mine The books of the company are destroyed, but there are records to show that 12,205 tons were shipped in 1870, and 10,100 tons in 1873, the last year in which the mine was worked. None of the ore raised by the new company was smelted in the Province, and of course the timber reserve of 20,000 acres acquired from the Government was not used for the purpose for which it was intended. Some time before closing down the mine the company had bonded the whole of its property for $300,000. In 1883 the whole property, including railways and rolling stock, mines, furnaces and works, dwellings at Blairton and Marmora and about 30,000 acres of land, were offered for sale by direction of the court, and Mr. T. P. Pearce of Cobourg (now of Toronto) became the purchaser, at the nominal price of $32,200. Mr. Pearce is still the owner, but the Big Ore bed at Blairton is filled with water, and the furnaces and works at Marmora are tumbling into ruins.

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[25] Journals, 1857, vol. xv. p. 438.

[26] The name of Big Ore bed was changed by the new company to Blairton mine, and forty cottages were built for housing the employés.

A BLAST FURNACE AT MADOC.

Another unsuccessful venture in Hastings.

A furnace for smelting iron ore with charcoal fuel was built at the village of Madoc in 1836 or 1837 by Uriah Seymour, and was worked with varying success for eight or nine years. The mine which supplied this furnace with ore is known as the Seymour mine, and is on lot 11 of the fifth concession of Madóc. Mr. F. E. Seymour, son of the furnace owner, gave the following account of the enterprise to the Commissioners appointed to enquire into and report upon the mineral resources of the Province :

"My father had a foundry as well as the furnace, and they began the manufacture of those articles at once. There were several tests or experiments made with the ore, as it required different treatment to that of ores he had been accustomed to in York State ; it contained neither phosphorus nor sulphur. I think smelting went on till 1844 or 1845. The experiments were very expensive, but I think the real cause of the stoppage was a lawsuit, together with a sudden drop in the price of iron. My father produced very good metal, and he said it was a very good ore to work when he got the proper flux. He mixed no other ore with it at all, but put loam with the flux, and this he considered to be the secret of his success."[27]

A fuller account of the difficulties experienced in working this furnace has been given by Mr. Thomas Macfarlane in the report of the Geological Survey, from information which the writer obtained from Mr. Seymour himself.

A record of furnace experiments.

"Limestone was used as a flux, and three different blasts were started with different materials (found in the neighborhood) for hearthstones. In each of these three trials the hearthstone was rapidly cut out by the slag, the furnace became unworkable and was blown out, always at a great expense for repairing the furnace and for fuel in heating it up. Mr. Seymour, supposing the bad quality of the hearthstones to be the cause of these misfortunes, procured a new hearth from Rossie, in New York, of the material used in the furnaces there. The furnace was again started, but, by way of precaution, with a blast at only one tuyere. The same flux was used as formerly, and the same slag was produced, cutting into the Rossie stone as much as it had ever done into the hearthstones previously used. It having been thus demonstrated that the former hearthstones were not at fault, since even the Rossie stone could not withstand the slag, Mr. Seymour decided to alter the flux, substituting for the limestone a sandy clay. This was done, the blast was stopped at the damaged tuyere, and introduced at the one which had been kept unused. Very soon the character of the slag changed. It became mild, did not cut into the hearthstone, and kept fluid and in motion long after it left the furnace. The iron was of excellent quality, but at this time the stock of charcoal became exhausted, it being impossible to procure charcoal burners to keep up the supply. Reduced to extremity, Mr. Seymour caused cordwood to be sawed up into lengths of two feet and used instead of charcoal. For seventy-five days he continued to work his furnace with the same fuel ; and with only one tuyere, producing a good slag and excellent iron to the extent of one ton daily. About eighty tons were produced in all during the blast and cast into stoves, potash-kettles, etc., besides a small quantity of pig iron. The latter found a ready sale in Belleville at $27 per ton and was considered of first-rate quality for machinery. Encouraged by his success in smelting with wood, Mr. Seymour repaired the furnace and started it again with wood alone as fuel, and with the two tuyeres at work. From two to two and a half tons of iron were produced daily, but it was of an inferior quality ; the castings made with it cracked in cooling. Mr. Seymour was led to suspect that this was caused by the wood descending too quickly and insufficiently charged into the furnace. That this did affect the quality of the iron was proved by stopping one of the tuyeres. The daily produce sank to one and one-quarter tons, but the good quality of the iron was restored, and the furnace kept in blast three months. The exact cost of the operation I could not ascertain, but Mr. Seymour assured me that according to his books this blast contributed somewhat to improve the financial position of the concern. The daily product of iron was however too small, and smelting with charcoal was again resumed, in the midst of which Mr. Seymour's partner was killed by an explosion in the mine. The difficulty of settling with his heirs became superadded to the financial difficulties of the concern, and Mr. Seymour's means having become exhausted he was obliged to suspend smelting operations." [28]

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[27] Report of the Commission, p. 389.

The failure of Mr. Seymour's venture does not appear to have been due to the quality of the ore, but rather to the primitive methods employed and to lack of sufficient capital where costly experiments had to be carried on with an ore the nature of which was not perfectly understood. The use of earth instead of limestone for flux seems to have been attended with very satisfactory results, a knowledge of which may prove to be valuable in the future treatment of our dense magnetic ores. From data furnished by Mr. Seymour to Mr. McFarlane it appears that he was able, even by the methods he employed, to produce pig iron with cordwood as fuel at a cost of $12 per ton.

BLAST FURNACE IN ESSEX COUNTY.

Smelting bog ore in Essex county.

A furnace to smelt bog ore was erected in 1831 by Messrs. Cahoon & Field at what is now known as the hamlet of Olinda, in the township of Gosfield. A passing reference to this enterprise is made in Smith's Canada, where it is stated that ore was found in the townships of Colchester and Gosfield, "large quantities of which used formerly to be manufactured at the furnace in Gosfield." [29] But this furnace is little more than a tradition even in the locality where it stood, and the few notes given here have been gathered from the old residents. The height of the stack was about thirty feet and the furnace is said to have been driven by a cold blast through one tuyere, but its daily capacity is not known. Sufficient quantities of ore were obtained within a radius of five miles, being chiefly of a variety known as "shot" ore, and it was smelted with a mixture of hardwood and charcoal. Stoves, plows, potash kettles, etc., for the needs of settlers were made at a foundry in connection with the furnace, but the principal market for the pig iron was found in the United States. There are no records to show what quantity of iron was produced by this furnace, nor the price at which the pig iron was sold. After having been in operation six years it was blown out in 1838, tradition says, "for want of funds." [30]

Experience of iron making in Quebec.

More than the lifetime of a generation has passed since the last pig iron was made in Ontario. Quebec has had a more fortunate experience, and a lesson of instruction to us may be found in it. I purpose therefore to follow the story of iron making in Ontario with some account of the production of pig iron from bog ores as carried on at the two seats of the industry in Quebec, in the valleys of the St. Maurice and St. Francis rivers. During the months of August and September of last year I visited the works at Radnor and Drummondville, and in February of this year I made again a hurried visit to Radnor along with members of the International Mining Convention. My information therefore has been obtained at first hand from the managers and officers of the works and from observations on the ground.

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[28] Report of the Geological Survey, 1866, pp. 109-111.

[29] Smith's Canada, vol. I. p. 27.

[30] For the information about the Olinda furnace here given I am indebted to Mr. Grove Whaley, a farmer in the township of Gosfield. "My father, Mr. Henry Whaley, now deceased," Mr. W. writes, "was foreman during its existence. I am too young to remember anything concerning it, being only fifty-five years of age. But I have interviewed some of the old residents here who are supposed to know, and am sending you what facts I can gather."

THE ST. MAURICE FORGES.

Furnace at St. Maurice village.

The group of furnaces known generally as the St. Maurice forges, from their situation on and near the river of that name, are five in number, and are in the counties of St. Maurice and Champlain. The oldest of these is at St. Maurice village, and has the name of being the second blast furnace on this continent, having been erected not later than 1737, and possibly four years earlier. The first furnace in America was built some years before this time by Governor Spotswood of Virginia, an interesting account of which is given by W. N. Adams in a recent number of the New York Iron Age,[31] who in November of last year exhumed it from the mass of debris, soil and vegetation which had buried it from human sight for one hundred and fifty years. The St. Maurice furnace, after an eventful history of nearly a century and a half, was blown out in 1883, having for the last twenty years of its existence been worked by John McDougall and his son George, and by the firm of John McDougall & Co. of Montreal. When John McDougall purchased the works in 1863 they consisted of one blast furnace and two Catalan forges. The hearth of the furnace was three feet square and four feet high, the diameter at the bosh was 8 feet 2 inches, and the height of the stack from the bosh to the throat was 20 feet. At first it was driven with a cold blast, but in the later years by a warm blast. The ore and charcoal were obtained in the immediate neighborhood, and about four tons of pig iron was produced daily. For three or four years the pig metal was cast into stoves, kettles, etc., but after 1866 the whole product of the furnace was sold to and used by John McDougall & Co. of Montreal for car wheels.[32] In 1874 the works were purchased by John McDougall & Co., and were carried on for about ten years longer, when the furnace was blown out for the last time owing to the scarcity of ore and fuel in the locality. The Catalan forges had been worked by John McDougall only two or three years. Their product was used in the manufacture of axes at St. Maurice, and of scythes at an establishment in Ontario.

Batiscan, L'Islet and Shawenegan furnaces.

Three of the other furnaces in the St. Maurice valley were the Batiscan, on Batiscan river, built in 1798, the L'Islet, and the Shawenegan, all of which are now idle. The Shawenegan furnace was a venture to smelt lean ores containing 10 per cent. of titanium, and was a complete failure. The L'Islet furnace was built by John McDougall at a distance of four miles from the old St. Maurice works. It also turned out a failure, as without railway facilities supplies of ore could only be got within the limits of carting distance, and after a few years the local fields were exhausted. Besides, the cost of carting pig iron to the market at Three Rivers left no profit to the producer.

THE FURNACE AT RADNOR FORGES.

Furnace at Radnor.

The furnace at Radnor Forges is situated on the river Au Lard, distant fifteen miles from Three Rivers. The pioneer of the industry at this place was Mr. Larue, an intelligent and enterprising French-Canadian, who conducted the business against heavy odds for several years. The works were commenced in 1860, and when completed the plant embraced a blast furnace with a capacity of from three to four tons per day, rolling mills, a foundry for casting stove plates, car wheels, etc., and a factory for horseshoe nails, part of which was located at Three Rivers. The township was largely bushland, and roads had to be cut and made over which to bring in material for construction, supplies of fuel, ores, etc., and to carry out the products of the works, the nearest marketing and distributing point being at Three Rivers on the St. Lawrence. Under such circumstances it is little wonder that Mr. Larue's enterprise failed. His estate passed into the hands of G. B. Hall & Co., who undertook to carry on the works as a side business with lumbering. This firm retained possession until July, 1889, when Drummond, McCall & Co. of Montreal became the purchasers, and organized the Canada Iron Furnace Company with an authorized capital of $300,000. The property consists of the furnace and charcoal works with 80 acres of land at Radnor, a car-wheel foundry at Three Rivers, mining rights on about 100,000 acres of land (embracing the township of Radnor) which had been granted to Hall & Co. by the Local Government, and an extensive tract of timber land along the St. Maurice river above Grand Piles. The furnace was leased for a short time to George McDougall, and operations were carried on until May, 1891, when it was blown out and dismantled, and the erection of a new furnace was commenced under the management of Mr. John J. Drummond, with designs prepared by John Birkinbine of Philadelphia, president of the American Institute of Mining Engineers. The shell of this furnace is constructed of boiler-plate, with a diameter of 13 feet 6 inches from the mantle ring to the top. The total height from the hearth floor is 40 feet, the crucible has a diameter of 5 feet and height of 4 feet 8 inches, the bosh a diameter of 9 feet and height of 8 feet 4 inches, and the stack proper a height of 27 feet with diameter of 9 feet at the bosh and 6 feet at the top. The furnace is water-jacketed from the base of the crucible up to the bosh-line, the jacket consisting of sixteen sections of cast-iron plate about 2¼ inches in thickness, through which runs a coil of one-inch pipe, the plate having been cast around the coil in the mould. Half a million gallons of water flows through these pipes every twenty-four hours, whereby the temperature of the interior fire-brick wall is kept down and its life preserved. The tuyeres, four in number and 3½ inches diameter, are water-jacketed also, and the hot-blast is driven into the furnace with a pressure of 3¾ lb., at a temperature of 850° F. So equipped the furnace had a capacity of 25 tons of pig per day of 24 hours. With a new Weimer blowing engine and four boilers now set up and working it is believed that the furnace can be driven up to 50 tons per day, but owing to a short supply of charcoal fuel the daily output during the winter has been limited to 25 tons. In practice the make will probably not exceed 40 tons per day. Gas from the stack furnishes fuel for the boilers and hot blast stove, and the supply will doubtless be ample when the furnace is driven to its full capacity.

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[31] New York Iron Age, April 13th, 1893, p. 843.

[32] The head of this firm, it may be remarked, is not the John McDougall of St. Maurice, nor even a relative of that gentleman.

A modern furnace built by the Canada Iron Furnace Company.

The blast was started in the new furnace on 12th March, 1892, and it is hoped that the campaign can be carried on for two years before closing down for repairs. For the first twelve months 6,500 long tons of pig iron was produced, the quality of which is claimed to equal the famous Salisbury brand.[33]

Supplies of bog ore.

The ore supply for the Radnor furnace is procured from a number of sources on both sides of the St. Lawrence, and consists almost wholly of bog ore or brown hematite. Magnetic ore from the Bristol mine on the Ottawa river is used as a mixture in small quantities, but it contains sulphur and requires to be roasted. Farmers are employed during the slack season in raising ores on their own or the company's lands and either drawing it to the furnace or delivering it at the nearest railway station. A large quantity is raised by the company's employés at Lac-a-la-Tortue on the line of the Grand Piles railway, nine miles from Radnor, where after being dredged and washed it is loaded on cars and taken to the furnace. This lake has been worked for thirty-one years, and although it only covers an area of five square miles the supply is believed to be still very large. In places the ore lies two feet in thickness, and where streams enter constant addition is being made to the deposit, the particles of iron being washed out of the sand area southward of the Laurentian hills. The following analyses of bog ores used at the furnace have been made by Prof. J. T. Donald of Montreal:

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[33] The St. Thomas Car Wheel Co. is now using 2,000 tons of Radnor pig iron a year. They volunteer the testimony that it is giving most satisfactory results in their car wheel mixture. "We have found that by the aid of it we can entirely dispense with the high-priced irons which we were formerly obliged to import, our records of tests showing an improvement of over 25 per cent. on the results previous to using your iron, in addition to which our percentage of loss has been greatly reduced." The Waterous Engine Works Co., of Brantford, report after two years trial that for cylinder and valve castings for engines it is at least equal to if not better than Salisbury iron, which they had previously used for this purpose.

——	1	2	3
Metallic iron	49.03	42.52	50.49
Manganese	1.78	1.18	0.23
Alumina	2.50	2.59	
Lime....................	0.32	3.47	
Silica	7.84	13.94	3.53
Phosphorus.........	.33	.302	.566
Sulphur.................	.09	.078	.15

The ore is very fine, yet it smelts freely and little of it is lost by blowing; but possibly the loss will be greater when the furnace is worked under higher pressure.

Production of charcoal fuel.

Charcoal is made partly at the works and partly at Grand Piles in kilns of rectangular and bee-hive forms, the latter being preferred. In the furnace yard there are eight rectangular and three bee-hive kilns, each having a holding capacity of 55 cords. At the Piles there are ten kilns, and five others are to be added. The supply of fuel there is practically inexhaustible, as the territory lies 70 miles along the St. Maurice river above the falls, and the Company has a right of cutting four or five miles back on either side. There are no obstructions on this stretch of the river, and the wood may be taken down in boats to the kilns at very low cost. About thirty per cent. of the coal is made from soft wood and seventy per cent. from hard wood, chiefly black birch and maple. The weight averages 22½ lb. per bushel and 110 bushels are required to smelt a gross ton, or say 98 bushels for a net ton of 2,000 lb. Much difficulty has been experienced in procuring help for the charcoal woods, owing to the exodus from that part of Quebec, and the company has a standing advertisement in the papers for a hundred men. Late last year twenty-five men were brought out from the charcoal-making districts of Sweden, and an effort is being made to bring out a hundred more this year. The Swedes have adopted a method of charcoal-making employed in their own country which may possibly lead to an important change in the company's fuel works. The timber is cut into lengths of ten feet, and after being rolled into heaps in the woods it is covered with earth and charred in the old-fashioned way. Constant additions however are made to the heap at one end, while from the other the finished charcoal is drawn out and carted off to the railway station or to a landing on the river. If this plan is found to be satisfactory it msy supersede the kilns, but the company will no doubt be guided in its course by the results of careful comparison.

Means for preserving the fuel supply.

It has been stated that the company's fuel supply on the St. Maurice is inexhaustible; yet it is not proposed to deal recklessly with that heritage. On the contrary, the intention is to take no tree for charcoal-making under

12 inches diameter, and all parts of it down to three inches will be utilized,—and to lessen the risk of forest fires the smaller branches and brushwood will be gathered into heaps and burnt in the spring or early summer of each year. By pursuing this plan it is confidently hoped that a continuity of fuel supply will be preserved upon a limited area along the river, and that there need be no fear of increase of cost on account of long haulage for many years.

Labor employed at the works.

The Radnor furnace gives employment to a large number of men, some steadily but most of them irregularly, as they are farmers who employ their spare time in raising ore or cutting wood upon their own lands and drawing it to the company's works or the nearest railway station. Sometimes the total reaches 850. The average of the past year was 600, but some of these were employed opening up new fields of ore and on work of a preparatory character, so that in proportion to the production of the furnace the number was larger than will be found necessary hereafter. But with the increased capacity of the furnace a large force will be required, especially in the ore fields and in the woods. The wages of ordinary laborers range from 80 cents to $1 per day, of furnace laborers from $1.15 to $1.40 per day, and of furnace men from $75 to $100 per month.

THE ST. FRANCIS FURNACES.

In the St. Francis valley, on the south side of the St. Lawrence, iron-making has been in progress for nearly a quarter of a century.

Locations of furnaces.

The first blast furnace in this district was built in 1869 on the Aux Vaches river, a tributary of the St. Francis, in the county of Yamaska. It was operated by the St. Francis River Mining Company for four years, during which 5,520 tons of pig iron was smelted from the bog ores in the locality, and in 1873 it was sold to John McDougall & Co. of Montreal. By this firm the works were carried on until 1880, when, upon the ores becoming exhausted, the furnace was dismantled.

In 1880 the same firm began to establish smelting works at the town of Drummondville, on the St. Francis river. One furnace, known as the Grantham, was built in that year, and a second, known as the St. Francis, in 1881. Both stacks are built of stone lined with fire brick, on four arches which form a square of 26 feet, and both are about 35 feet high. The bosh of the Grantham is 10 feet in diameter and that of the St. Francis 9 feet, the capacity of the former being 7 tons and of the latter 6 tons per day. Both furnaces utilize gas from the stack to heat the blast, the temperature of which is 400° to 450° F. The blowing cylinders are driven by a Leffel wheel of 56 inches diameter, and the pressure ranges from three-quarters to one pound per square inch. The blast is driven into each furnace through five tuyeres of 1½ inch diameter.

Supply of bog ore.

Bog ore is obtained from the districts south and east of Drummondville, at distances ranging from four to twelve miles. The bulk of it is raised by the firm's employés, washed by seiving in shallow wells, and drawn to the yard by the firm's own teams; but considerable quantities are gathered and delivered by farmers and jobbers. As washed this ore will analyze 50 per cent. of metallic iron, and yields in the furnace 40 to 42 per cent. When drawn by teams direct to the furnace it costs $1 per 1,000 lb., and when brought in by rail $1.25. Farmers on whose land the ore is mined are paid by the firm a royalty of 7½ cents per 1,000 lb., or 15 cents per short ton, which is equivalent to about 38 cents per ton of pig. The ore occurs in beds ranging from 3 to 12 inches in thickness, and sometimes to 20 inches. It is found in the sand or on the edges of bogs, on islands in the bogs, and occasionally in peaty deposits.

Charcoal fuel.

The charcoal for fuel is made in rectangular kilns on the furnace grounds from balsam, spruce and small quantities of white birch and soft maple, at a cost of about five cents per bushel. Wood for the purpose is delivered at

$1.25 per cord of 138 cubic feet, this being the French measure. Twenty-five bushels of coal is sufficient to smelt 650 to 700 lb. of ore, which is the usual charge for the furnaces.

The average length of a campaign is about ten months, at the end of which time it is found that the lining of the furnaces is in need of repairs; but both furnaces are hardly ever shut down at the same time. The whole output is used in the manufacture of car wheels at the company's works at Montreal, where it is regarded as equal to the production of the Salisbury furnaces. Sometimes large stocks accumulate, the quantity of which is determined by the requirements of the car wheel foundry. At the time of my visit in September about 2,500 tons of pig was piled up in the stock yard, although it might then be sold to dealers at $27 per ton.

Employment of labor.

With one furnace in blast 36 men are employed, and with the two 44 men. In the bush an average of 150 men is maintained for the year round, making ore, wood and limestone. The stone is obtained in the township of Grantham, about four miles from the furnaces, and 40 to 50 lb. is sufficient flux for a charge. The highest wage paid at the furnaces is $1 per day, and the average is 90 cents, which with a free house makes a round rate of $1. In the bush men taking out ore are paid $1 per day, and axemen are paid 50 cents per cord. In round numbers those two small furnaces at Drummondville give employment to 200 men, whose earnings in a year are $60,000.

THE BOUNTY ON PIG IRON.

Rate of the Government bounty.

With the object of encouraging the production of pig iron in Canada the Dominion Parliament ten years ago adopted the bounty system, and provision was made for the payment of $1.50 per ton of 2,000 lb. This bounty was continued until the end of the fiscal year 1888-89, when for the next three years it was reduced to $1 per ton. Beginning with 1st July, 1892, the rate was increased to $2 per ton, and payment of bounty at this rate has been authorized for a period of five years.

The following table gives the quantity of coke and charcoal pig iron made in the Dominion in each fiscal year since provision was made for payment of the bounty, and also the amount of bounty paid as shown by returns made to Parliament, the weight being expressed in tons of 2,000 lb.:

Year.	Coke Iron.		Charcoal Iron.		Total Pig Iron.		Bounty paid.
	tons.	lb.	tons.	lb.	tons.	lb.	$
1883-4	25,472	0399	3,855	1797	29,328	0196	44,089.91
1884-5	21,174	0166	4.595	1135	25,769	1301	38,654.91
1885-6	22,463	1426	3,715	1770	26,179	1196	39,269.56
1886-7	35,464	1520	7,255	1178	42,720	0698	64,081.41
1887-8	16,120	1888	4,646	0329	20,767	0217	31,151.58
1888-9	20,413	1200	4,404	1880	24,818	1080	37,233.27
1889-90	20,775	0048	2,594	0952	23,369	1000	25,697.27
1890-1	15,849	1632	4,303	0515	20,153	0147	20,153.05
1891-2	26,066	0528	4,228	0306	30,294	0834	30,294.37
1892-3 to Feb. 3.	24,678	0284	5,770	1870	30,458	2154	57,952.83
Totals......	228,478	1091	45,370	1732	273,849	0823	388,578.16

Coke iron.

All the coke iron in the first nine years was produced at one furnace, that of the Londonderry Iron Co. of Nova Scotia; but since the opening of the present fiscal year another furnace has commenced to make coke iron in that Province, viz: the New Glasgow Iron and Coal Co., which has produced 6,130 tons, and has been paid a bounty of $12,260 thereon. The Londonderry Company on 222,348 tons has been paid in bounties $309,886. For the first nine years its average yearly make was 22,644 tons (or 62 tons per day), and the average yearly bounty was $30,575. The statistics of those nine years do not afford evidence that production was encouraged by the bounty. In the last two years during which $1.50 per ton was paid the output was less than in the first two years under which the bounty was $1 per ton, while in the third year of the lower bounty the output was greater than in any except one of the preceding years. The present year promises a considerable increase, which may be due to the larger bounty now paid; but production will always be more influenced by the conditions of the market than by the rate of Government bounty.

Charcoal iron.

The charcoal iron is wholly the product of Quebec furnaces, viz.: of the two at Drummondville and the one at Radnor Forges, the latter having made in the whole period 12,464 and the former 32,906 tons. During the first nine years the Radnor furnace produced 8,474 tons, upon which it received a bounty of $10,686; but its product to February 3rd of the current fiscal year, with the new furnace in blast, has been 3,990 tons, and the bounty paid has been $7,081. The Drummondville furnaces produced in the first nine years 31,126 tons, upon which a bounty of $44,762 was paid. The average yearly make of these Drummondville furnaces for the nine years was 3,458 tons, ranging from 2,070 tons in 1889-90 to 6,495 tons in 1886-7. It will also be noticed that the largest production of coke iron was in the last named year. Another charcoal furnace has been started in blast this year in Nova Scotia, but the table does not include any portion of its product.

Ontario is a large consumer of the coke and charcoal irons made at those furnaces, and she imports large quantities from Great Britain and the States besides. But although she has great deposits of iron ores within her own borders, and extensive forests of timber suitable for the making of charcoal fuel, as well as much capital waiting for investment, she does not produce a ton of pig iron to supply her own large needs.

ADVANTAGES OF PRODUCTION IN ONTARIO.

The bonus and the tariff duty.

The duty imposed by the Canadian tariff on pig iron is $4 per ton of 2,000 lb., and the bounty given by the Dominion Government to the owners of blast furnaces producing pig iron from native ores and with native fuel is $2 per ton. The Canadian ironmasters therefore enjoy an advantage in their own market over foreign competitors (in which of course the British ironmaster is included) of three-tenths of a cent per pound, or $6.72 per long ton, which is the rate of protection afforded by the United States tariff. In Quebec and Nova Scotia this is regarded as sufficient encouragement for the industry, and in the opinion of some practical men who know conditions in this country and who have a full knowledge of the cost of producing pig iron in the neighboring States, the charcoal iron industry would seem to require no further aid in this Province. We have abundance of hardwood timber suitable for making the finest quality of charcoal fuel; and in the same forests, convenient to lines of railway already built, we have extensive deposits of iron ores, several of which have been opened and could be worked again at little or no cost for machinery and development. But the cost of production varies so much at different furnaces that it would be impossible to say with certainty what that cost might be at any given point in Ontario. This can be determined only by actual practice; and so much depends on the skill of workmen, the business capacity of managers, the suitability of a furnace to do economic work, the cost of assembling ore, fuel and flux, and various other considerations, that it would be useless to enter upon a discussion of the question of cost in the abstract. Practical men will investigate for themselves. Past experience in this Province is of some value, but chiefly for the lessons which it affords of practices to be shunned. Lessons of more value may be gained from the experience of ironmasters in Quebec and Nova Scotia in our own country, and many more from the experience of iron-

Favorable conditions for producing charcoal iron in Ontario.

masters in the United States. It is not for the lack of capital that there are no blast furnaces here, but rather for lack of men with confidence and enterprise to invest their money in the business of iron-making as they do in other manufactures, in trade, or farm lands, or bank stocks, or corner lots. They have been educated to invest money along these lines, and they know that within certain limits they may do so securely. The time will come no doubt, if it has not already arrived, when men with capital will turn their attention to the great dormant resources which Ontario possesses in its belts and beds of iron ores and forests of hardwood timber, and some will be found with courage to venture their money in starting an industry. But before embarking in the enterprise they will satisfy themselves by enquiry that the conditions of success are favorable; and although there may be disappointments, the experience of the world proves that it is by such men industries are built up. Self-reliance is of infinitely greater value to a business man than the best devised scheme of Government bounty alone can be; and there are many who believe that the bounty on pig iron provided for by the Canadian Government, in connection with the measure of protection afforded by the tariff, is ample in its liberality. Australia at the present time is passing through a severe commercial crisis, and the Melbourne correspondent of the London Times, in writing of the situation to that paper, opens his letter with this observation: "In order to understand the present position of Victoria, you have but to remember," some one said to me the other day, "the habitual attitude of the native-born Australian, who, wherever he stands, must lean against a post." And the correspondent remarks that the more the financial situation of that country is studied the more profoundly true the observation will appear. The depression through which Victoria is passing, he says, is to be described in general terms as the outcome of leaning against posts instead of trusting to the natural power of standing upright and depending on one's own energy and resources. It is to be hoped that no comment of this sort will ever be necessary in describing the Ontario man; but if he is taught to rely on subsidies and bonuses instead of upon his own skill and enterprise, he also may come to possess that fatal weakness of the back which needs the support of a Government post. There are ways doubtless in which Government help can and should be given, the most natural and useful of which would appear to be the collecting and publishing of information on all the natural resources of the country, and on the best economic methods whereby raw material may be utilized and converted into finished article, to the mutual advantage of producer and consumer.

Need of self-reliance and enterprise.

Best form of Government help.

Diversity of production an element of commercial prosperity.

Thirty years ago the industries of Ontario were few in number, the main sources of wealth being the wheat and barley grown by the farmer in the frontier and the lumber and timber sawn and cut by the lumberman in the backwoods. Then the failure of a grain crop or an overstocking of the lumber and timber markets was a serious matter to the trade and commerce of the country; and in Australia today the situation is much the same, with wool-growing and mining as the chief industries. But now we have a diversity of industries; in agriculture alone the variety of products gives evidence of surprising development, and to this diversity we owe in very large measure our immunity from commercial and financial distress. To open up and work our deposits of iron ore, to build blast furnaces and smelt ore into iron, and to manufacture iron into the endless forms for which it is required in the service of man, would be to make an important and substantial addition to the diversity of our industries, and so to broaden the foundations of the country's prosperity. But no new enterprise ought to be undertaken rashly. "Make haste slowly," is a good maxim in every human undertaking. The gourd which came up in a night to shelter the head of an angry prophet, a worm smote it, and it perished in a night.

III.

THE IRON ORES OF ONTARIO.

Extent of the mineral-bearing formations in Ontario.

The Laurentian, Huronian and Cambrian formations constitute the whole northern portion of the Province from the Ottawa river to Lake-of-the-Woods, saving portions of the Moose river basin towards James bay, where there is an outcropping of the Devonian. They form the whole region from Lake-of-the-Woods to lake Superior, the northern and eastern shores of the latter lake as well as of lake Huron, and nearly the whole country thence eastward to the Ottawa river and southward across the Thousand Islands in the St. Lawrence to the Adirondack mountains in New York. These are the chief mineral-bearing formations of the earth's crust, and consist of talcose and other slates, quartz rock, gneiss, limestone, serpentine, granite, syenite and other subordinate masses. The limestones and serpentines yield marbles of beautiful descriptions, the felspathic rocks furnish good porcelain clays in their decomposition, copper and nickel ores are found in several localities, veins of gold ore occur in the county of Hastings, on Lake-of-the-Woods and at a number of intermediate places, silver in various localities in the Cambrian rocks, plumbago is abundantly developed, and the whole of the older series appears to be associated with large and valuable supplies of the magnetic and specular oxides of iron. "Specular and magnetic oxides of iron are disseminated in scales and grains, both in the gneiss and the limestone; but there are also important interstratified beds of these iron ores varying in thickness from a few feet up to several hundreds, those of the magnetic oxide being the thicker and more numerous. Some of the thickest of these beds are interstratified with layers of limestone, and as far as known most of them appear to be either associated with the great limestone bands, or to be not far removed from them in stratigraphical place."[1] "The magnetic oxide sometimes occurs in masses made up of coarse grains; at other times the ore is fine grained and almost compact; more rarely it occurs in regular octahedral crystals. This ore is found only in crystalline or metamorphic rocks; and the deposits of it in Canada occur in the Laurentian series, or in the crystalline rocks of the eastern palæozoic basin. In the former it is met with in beds of great extent and thickness."[2] Professor Emmons, in his final report on the geology of New York, mentions the existence in the district bordering on lake Champlain and the St. Lawrence of upwards of seventy veins and beds of these ores, ranging in thickness from two to one hundred and sixty feet, while two others are respectively five hundred and fourteen and seven hundred feet in thickness. One of these larger beds has been followed for two and a half miles, and the amount of ore which it contains may be seen when it is stated that in a mile every five feet in depth would yield about one million tons of pure iron. Valuable deposits of the same ores have been discovered in Ontario in the townships of Marmora, Madoc, Bedford, Bastard and other places, and when we reflect upon the great extent of the mineral-bearing formations here, in so many parts of which the magnet is deflected from its meridian, presumably by the proximity of magnetic ore, it is not unreasonable to hope that search may disclose great bodies of iron ore over wide areas of territory. In the northern peninsula of Michigan and in Minnesota, where the formations are the same as in sections of Ontario north of lake Huron and northwest of lake Superior,

Specular and magnetic oxides of iron.

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[1] Geology of Canada, 1863, p. 26.

[2] Ib. p. 673.

iron ores abound on a larger scale than anywhere else in the United States, and it can hardly be doubted that a thorough search on the Ontario side would result in the discovery of the same ores in equal abundance and richness.

LOGAN'S REPORT ON ORES OF THE OTTAWA VALLEY.

Ores in the Ottawa valley.

Among the minerals found associated with the formations of the Ottawa valley are the magnetic and specular oxides of iron, bog iron ore, brown ochre, galena, copper ore, plumbago, etc. In his report for 1845-6 Sir William Logan expressed the opinion that the great spread in the valley of the Ottawa of the metamorphic rocks with which the ores of iron seems to be so largely associated in other parts of its extension on both sides of the St. Lawrence makes it very probable that the banks of the Ottawa and its tributaries will be supplied with vast stores of them. In Hull, on the Quebec side of the river, a bed of the magnetic ore is met with for a distance of about one mile in syenitic gneiss, interstratified with white crystalline limestone holding mica and graphite, which varies from twenty to forty feet in thickness.[3] Where the ore has been acted on by the weather it breaks up into grains which, it is claimed, adds considerably to its value for smelting purposes Assuming the breadth of the vein to be twenty feet, Sir William Logan calculated that every fathom forward with a vertical depth of a fathom would probably yield not less than fifty to sixty tons of pure metal. An analysis of this ore made by Sterry Hunt gave 96.09 per cent. of magnetic oxide of iron (equal to 69.65 metallic iron) and 3.18 of silica and graphite. On the Ontario side of the river ores occur in the townships of Bedford, Bastard, Sherbrooke and McNab. The Sherbrooke bed occurs on the north shore of a beautiful sheet of deep water called Christie's (or Myers) lake, and is described as containing a mass of very great importance, the bed having a thickness of about sixty feet. An analysis by Sterry Hunt gave 87 per cent. magnetic oxide of iron (equal to 63 per cent. metallic iron) and 12.08 silica and mica mechanically mixed. On the south side of the lake a bed of twelve feet of magnetic iron occurs in gneiss. Specular ore exists in the township of McNab, on the west side of Chats lake, an expansion of the Ottawa, an exposure of which showed a thickness of twelve feet, and outcroppings have been traced a length of one mile. The ore presents a red, earthy aspect on the weathered surface, but in fresh fractures it has a purplish red hue, and exhibits an aggregation of minute shining scales. There are some impurities arising from the presence of small quantities of quartz and calcareous spar, but taking the breadth at twelve feet it is probable that the bed would yield not less than twenty-five tons of pure iron for every fathom forward with a fathom in depth. A specimen analysed by Hunt gave 84.10 peroxide of iron (equal to 58.87 per cent. metallic iron) 4 of silica, 8.80 carbonate of lime and 3.10 of water by loss. "The silica and carbonate of lime" Dr. Hunt added, "are accidental impurities, and are disseminated in little spots and veins. The ore is, when pure, a peroxide of iron only."[4]

Hull mines.

Deposits in Renfrew and Lanark.

Specular ore in McNab.

IRON ORES AT THE FIRST WORLD'S FAIR.

Exhibit of Ontario iron ores at the first World's Fair,

At the World's Fair held in London in 1851 a number of specimens of iron ore from Canada were exhibited, most of which were collected by the and Sir William Logan's report thereon.

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[3] Geological Survey of Canada, 1843, pp. 41-2. Canada possesses in the crystalline ores of the Laurentian rocks and in the iron slates of the Eastern Townships "inexhaustible supplies of rich ores of this precious metal which may compare with those of the United States or with Sweden. It is from these magnetite and red hematite ores, reduced by charcoal, that the finest iron of the world is manufactured ; and it cannot be doubted that skilled labor and capital will one day make the iron mines of Canada great sources of national wealth." Geology of Canada, 1863, p. 687.

[3] According to the Geology of Canada, 1863, the thickness of this bed is ninety feet, p. 673.

[4] Geological Survey of Canada, 1845-6, pp. 75-8 and 122-3. Geology of Canada, 1863, pp. 673-4.

Superiority of Swedish iron.

Effect of the exhibit on European visitors.

officers of the Geological Survey. This Province was represented by the following exhibits: Large blocks of magnetic ore from Marmora, Madoc, Bedford, South Crosby and South Sherbrooke, specimens of specular ore from the Wallace mine location, and a large block from the township of McNab. There were shown also samples of pig iron made from the ores of Belmont and Marmora by the Marmora Iron Company.[5] Referring to the evidence which this collection gave of the vast supplies of iron with which the Province is enriched, Sir William Logan observed that it appeared to arrest the attention of all. The British miner who is accustomed to follow beds of ore of six inches and one foot in thickness containing 30 or 40 per cent. of iron naturally regarded with surprise great blocks of it from beds of 100 and 200 feet in thickness, yielding 60 to 70 per cent. of metallic iron; but the British smelter upon being informed that no mineral coal existed in the vicinity of the ore did not appear to apprehend that any competition would arise to interfere with the supply to Canada of those qualities of iron which are made in the United Kingdom from the deposits of the Carboniferous era. Some Sheffield manufacturers of steel, whose supply of iron was obtained from Sweden at prices varying from £10 to £33 per ton according to quality, seemed desirous of ascertaining the cost that would be required to smelt the magnetic oxide in Canada, and to them it was a question of the wages of labor rather than anything else, assuming the requisite skill to be introduced into the country, whether any competition could be established in favor of Canada, seeing that the ore and fuel in the two countries are the same. "The superiority of Swedish iron for steel is unquestionable; its character for such a purpose stands higher than that of any other country; it is made from the magnetic oxide, and between the magnetic oxides of Sweden and some of other countries chemical analysis instituted for the express purpose of comparison has, it is said, been unable to detect any difference. It might be supposed therefore that smelted with charcoal and generally treated in the same manner, there ought to be no essential difference in the quality of the iron. Experiment however does not prove this to be the case, and there may be some delicate difference (possibly the presence of rare metals in small quantities) which may yet have escaped the investigations of science, to account for the results. The ores selected for comparative trial may have been the produce of geological formations different from those of Sweden, but it is not likely that this can give the essential cause of difference, as even in Sweden the ores of different mines in the same geological formation, all yielding good steel iron, give differences of quality which are so uniform as to produce a regular and constant difference in price. The geological formations yielding the magnetic oxides of Canada and those of the United States, where they prevail in equal abundance, are identical, and it is probable they are both of the same formation as that of the Swedish mines. The practical experiments on Canadian ores are still so few that nothing can yet be proved from them. But in the United States the American smelter has been able to compete with the Swedish, only on this side of the Atlantic, and that with the assistance of a considerable protective duty." Referring to the general effect produced by the exhibit upon the minds of visitors, Sir William Logan remarked that the Canadian ores were examined with great care and attention by the agents of Russia, who were struck with wonder that such prodigious source could be found in any country but their own; while the public in general, without taking into consideration the question of present application to profitable uses, seemed to regard the great beds of magnetic oxide as national magazines in which was stored up a vast amount of a material indispensable to the comfort and progress of mankind, which it is always satisfactory to the inhabitants of a country to know is within their reach and control should circumstances arise to render its application expedient or necessary. Referring particularly to the specimens of specular ore from the township of McNab, Sir William reported that it was regarded as "a very beautiful ore, the uniform quality of which would render it one of much more easy fusion and management than the magnetic oxides, while it would probably produce an iron of excellent quality."[6]

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[5] Geological Survey of Canada, 1851-2, p. 39.

ORES ON THE RIDEAU CANAL.

Specular ore Bastard.

It was about this time that Mr. Murray of the Geological Survey began to examine the country along the Rideau canal, and to report on occurrences of specular iron ore in the sandstones and conglomerates of the Potsdam formation in the ninth and tenth concessions of Bastard, where it extends over a considerable area in thin layers. Although no evidence was observed of the fact, Mr. Murray expressed the opinion that in some portion of the distribution the quantity of ore might be found to increase to a productive amount. "The concentration of the ore is greatest towards the middle of the bed, where nodules and patches of pure red hematite, running with the stratification, occur at intervals of a few inches, the thickness they display not exceeding a couple of inches. About forty years since an attempt was made to mine the ore for the supply of a furnace erected at Furnace Falls, but the quantity in the locality worked was not sufficient to give a profitable result. The Potsdam formation is similarly characterized on the twenty-third lot of the same concession of the township, and also on the ninth concession of Lansdowne, and the ferruginous deposit would thus seem to extend over a considerable area."[7] Mr. Murray goes on to say that in the state of New York an iron ore of this description occurring under similar circumstances in the same formation has been made economically available, and in those parts of the district under consideration in which a deep red color characterizes the formation it merits attention.

Magnetic ore in South Crosby.

In the adjoining township of South Crosby Mr. Murray found a large body of magnetic iron ore on an island in Mud lake, not far from Newboro on the Rideau canal, which is described as a mass of considerable purity running northeast and southwest, apparently with the stratification, and having a breadth of about seventy yards.[8] Referring to these locations six years later, Sir William Logan stated that 2,000 tons had been mined by Messrs. Chaffey of Kingston and exported to Pittsburgh by way of the Rideau canal and lake Ontario, the price on board of lake craft being $2.25 per ton. In 1854 the ore bed at Hull, on the Quebec side of the Ottawa river, was opened and mined by Messrs. Forsyth & Co., iron smelters of Pittsburgh, with the object of supplying ore to their own smelting works. It was transported from Hull through the Rideau canal to Kingston, and thence shipped by lake craft to Cleveland, but Sir William Logan remarks that as the Newboro bed was much nearer to Kingston and more favorably situated for loading into canal barges, the ore from it could be placed at the shipping port at a lower cost, the effect of which was that Forsyth & Co. began to take their supply from Messrs. Chaffey. During the season of 1859 the quantity of Newboro ore exported was 4,000 tons, making with the previous year's export 6,000 tons. "The trade in the ore," Sir William observed, "has naturally excited a keen search for other deposits in favorable positions, and Messrs. G. Chaffey and Brothers, who mine the South Crosby ore, have informed me that this search has been rewarded by the discovery of the continuation of the ore bed across the first and second lots of the sixth range of North Crosby. They have also informed me that a deposit of ore has been met with on Black

Iron ores on the Rideau canal mined and shipped to the United States.

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[6] Geological Survey of Canada, 1851-2, pp. 45-7.

[7] Geological Survey of Canada, 1851-2, p. 81. The furnace here referred to is the one mentioned on p. 13 ante, the first blast furnace built in this Province.

[8] Ib. p. 80.

lake in the eighth lot of the fourth range of Bedford, and another one on the sixth lot of the third range. These may be a continuation of the bed which has been described by Mr. Murray in a previous report as existing on the twenty-first lot of the ninth range of the same township."[9] In the Geology of Canada 1863 (p. 674) the ore of this mine is reported as forming a bed 200 feet thick, running northeast and southwest in gneiss, adjoining the crystalline limestone.

Bog ore in Bastard.

A bed of limonite or bog ore was observed by Mr. Murray on lot twenty-one in concession seven of Bastard, which was found to be about two feet thick in one place, and bounded on one side by an escarpment of rock. Dr. Hunt describes it as very pure in appearance, and an analysis showed it to contain 77.80 peroxide of iron, .061 of phosphoric acid, 10.5 water and the remainder of sand and alumina.[10]

BILLINGS' ESTIMATE OF QUANTITY.

Estimates of iron in ore beds of the Ottawa valley and eastern Ontario.

Hull mine.

Crosby mine.

South Sherbrooke and McNab beds.

Marmora ores.

A remarkable paper bearing on the quantity of ore in some of the foregoing mines and properties appeared in the second volume of The Canadian Naturalist and Geologist by Mr. E. Billings, a gentleman who was for many years connected with the Geological Survey. Referring to the Hull mine on the Ottawa river, he described it as one hundred feet in thickness, instead of twenty feet as had been supposed by Sir William Logan, and stated upon the authority of Dr. Hunt that it contained about 70 per cent. of pure iron. The limits of the mine had not at that time been traced, but Mr. Billings had no doubt that this bed underlies the country for many miles in one continuous sheet. "It is not a vein filling up a perpendicular fissure in the earth's crust, but a bed lying between the strata of the formation. Where it is exposed it forms a dome and dips away in all directions. How far it extends cannot be ascertained, but granting that 500 fathoms is its limit each way, then it would contain 250,000,000 of tons of pure iron." This mine is situated five miles from the city of Ottawa, on the Quebec side of the river. Of the Crosby mine on the Rideau canal Mr. Billings said: "This bed is said to be nearly 200 feet thick, and should its yield be as great in proportion as that of the Hull mine, it would contain in a superficial area of 1,000 fathoms 500,000,000 of tons of pure iron. This enormous bulk of metal can scarcely be conprehended. Were the whole iron mining force of Great Britain and the United States at work for one hundred years upon such a deposit, they would not, at their present rate of production, exhaust it." Then as to the deposit in South Sherbrooke, he described it as a bed 60 feet in thickness, and estimated its probable contents at 100,000,000 tons of pure iron. Of the specular iron ore location in the township of McNab, he said: "The bed is twenty-five feet thick, and contains perhaps 50,000,000 of tons to the 1,000 fathoms square. It is situated about one mile from the village of Arnprior, thirty miles from the city of Ottawa, and in the midst of an abundance of water power." After noting that the beds from which the Marmora iron works were at that time supplied might be estimated as containing 100,000,000 tons, Mr. Billings proceeded to say: "We have therefore in the above five beds in round numbers 1,000,000,000 of tons—a quantity sufficient to yield 1,000 tons of iron a day for 3,000 years, could furnaces be erected and kept in operation capable of smelting that quantity. And as the deposits above-mentioned are only a part of the known iron wealth of the Province, and in all probability but a small proportion of that which is at present unknown, but must be brought to light as the Laurentian region becomes settled, it is clear that we may safely consider the stores of this metal inexhaustible."[11] Mr. Billings spoke with the authority of an old officer of the Survey, and although his fame rests upon studies made in another department of the work of the Survey, viz., palæontology, it cannot be supposed that he made such explicit reference to the possible supply of ore in the localities mentioned without careful examination and inquiry. Yet in view of the pitiful results of mining operations at Hull and South Crosby, it may well be questioned if in respect to his estimates of quantity, description of quality and claim for economy of working, there is not an air of extravagance. One can hardly credit the possibility of the existence of the equivalent of 500,000,000 tons of pure iron on the line of the Rideau canal, which could be mined, loaded upon canal boats, delivered at Kingston and transferred to lake vessels for Cleveland or Oswego at $2.25 per ton, when iron ore was selling for $6 per ton at Pittsburgh, and yet such a mine to lapse into idleness. Even at present prices and in the face of a duty of 75 cents per ton, its working ought to yield a good margin of profit. I am not aware that Mr. Billings' estimates of the quantities of ore in these localities have ever been disputed. But we shall see farther on why the Chaffey mine failed to realize expectations.

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[9] Geological Survey of Canada, 1858, pp. 47-8.

[10] Geological Survey of Canada, 1851-2, pp. 82 and 105.

[11] The Canadian Naturalist and Geologist, vol. II. first series, pp. 23-4.

THE HASTINGS AND FRONTENAC DISTRICTS.

The existence of iron ore in the districts north of Kingston, Belleville and Cobourg was known at an early period in the history of the country, and we have seen that as long ago as 1823 a blast furnace was erected in the township of Marmora to smelt ores taken from the Big Ore bed at Blairton. Frequent references to the occurrence of magnetic iron ores in those localities are made in the early reports of the Geological Survey, yet it was not until 1852 that the region was visited by an officer of the Survey. In that year Mr. Alexander Murray explored the country lying between the township of Bedford in Frontenac and the river Severn; the object being, as stated by Sir William Logan, to trace the general outcrop of the lower fossiliferous rocks along the more mountainous metamorphic group which comes from beneath them on the north, and to ascertain the nature of the economic materials associated with both at moderate distances from their junction. The following account of the occurrence of magnetic and specular iron ores in the region traversed by him is taken from Mr. Murray's report:

Report on the magnetic and specular ores of the region by Murray.

"Ores of iron are very generally disseminated through the rocks of the Laurentian group, and when existing in large workable masses appear to be usually either in contact with or at no great distance from the crystalline limestones. The localities where the magnetic oxide was chiefly met with were in Bedford, Madoc, Marmora, Belmont and Seymour; and although the information received by me from time to time makes it appear probable there must be many more places where it abounds, I did not see except in these townships any instance where the material was in sufficient quantity to warrant the experiment of working it. One of the localities visited was on the 21st lot of the ninth concession of Bedford, where the magnetic oxide occurs at the foot of a ridge of gneiss, associated with a greenish rock consisting of an aggregate of greenish felspar, and numerous large prismatic crystals of greenish hornblende in a pale fawn-colored calcareous base. The bed to which it belongs is not well exposed as it lies in a hollow, the greater portion of which at the time I was there was covered with growing grain; but its presence was indicated in the same position and associated with the same minerals by the fragments strewed upon the surface for about a quarter of a mile in a northeast direction from where it was first seen. To the westward there is a fault running north 25° west and south 25° east which throws the ridge of gneiss about 150 yards to the southeastward on the southwestward side; but although a careful search was made for the continuation of the ore, both in the direction of the dislocation and on the southwestward continuation of the ridge, it was nowhere found. The bed of ore did not appear to be over three

In Bedford.

or four feet thick. Immediately on the southeast of the ridge crystalline limestone comes in with its associated beds, dipping on the average northwest at an angle of 30°. Another exhibition of the ore occurs in Bedford, near the northeast end of Bob's lake, supposed to be in the twenty-fifth lot of the fifth concession. It was found in small fragments near the foot of a ridge of crystalline limestone, but nowhere in place, and is probably of no economic importance.[12]

In Olden.

"I was informed by an Indian that iron ore had been found a little way to the north of the portage, about half way between a place called the Beaver Dam and Cross lake in Olden, but although a whole day was expended in the search it was nowhere found, except in small specks or crystals in the felspathic rock of the country.

In Madoc, Marmora and Belmont.

Loadstone.

"The deposits of iron ore in Madoc, Marmora and Belmont, some of which have long been known and have been worked will probably hereafter become of great commercial importance. The ore, which was formerly smelted at the village of Madoc by Messrs. Seymour & Co., and produced an excellent quality of iron, was mined on the eleventh lot of the fifth concession of the township. The bed appears to run through a black, soft, micaceous rock, and holds a course which, as far as it was traced, was about west by north and east by south, while the slope of the bed, which is towards the south, was between seventy-five and eighty degrees. The greatest observed breadth of the bed appeared to be about thirty feet, and its average would probably not fall short of about twenty feet. A material similar to the soft, black, micaceous rock, which accompanies the bed of ore on each side, appears every now and then to cut it diagonally in thin belts. In one place the bed is said to have been thus cut at distances of from every three to ten feet, and in another there was an unbroken part with a length of fifty feet. The ore is very black and very fine-grained, and while the whole body of it is magnetic, some portions of it have polarity, one end of a fragment repelling and the other attracting the north end of the magnet. When the ore is bruised with a hammer on these portions of the bed, or on fragments taken from them, the particles adhere to one another and stand up on the mass as they would on a magnet, the ore being, in short, a natural magnet or loadstone. The portions which have polarity appear to run across the ore-bed at right angles. Nodules of actinolite or green fibrous pyroxene, made up of radiating crystals, are disseminated in the ore, and yellow uranite is found investing small cracks. I was informed that in the general direction of the bed traces of ore have been met with twice to the eastward, in the tenth lot of the sixth and the ninth lot of the seventh concession, and to the westward in the twelfth lot of the fourth concession, the distance between the extreme points being about two miles.

Big Ore bed, or Blairton mine, in Belmont.

"On the eighth lot of the first concession of Belmont is situated the bed of magnetic oxide which yields the ore formerly smelted at the Marmora iron works. It is commonly known as the Big Ore bed, and has usually been called a hundred feet thick; it appears however not to be a single bed, but a succession of them, interstratified with layers of greenish talcose slate and crystalline limestone, occupying a breadth across the strike and back from Crow lake, into which it obliquely runs, of about eight chains. The general strike of the strata appears to be about south 40° east, and the slope towards the northeastward from 25° to 50°. At one place, on a surface of greenish colored mica slates, underlying coarse disintegrating crystalline limestone, the dip was north 62° east at an angle of 50°; but surrounded by the strong magnetic attraction of the ore bed, the compass could not be relied on as giving a true bearing. Crystalline limestone overlies the mass, and the first hundred feet of the metalliferous strata show a vast bulk of ore, the upper portion of which chiefly was mined for smelting. Of the lower part, thirteen feet towards the bottom were also mined, but not to the same extent. Associated with the ore and the talcose slates accompanying it, diallage rock and serpentine occur, and a pale green rock, translucent on the edges, and harder than serpentine, deriving its character from the presence of pistachio green epidote; through this green rock the ore is usually very thickly disseminated. The upper metalliferous beds suffer in quality from the presence of iron pyrites, from which the lower beds appear to be wholly free, thus yielding a much finer quality of ore. This part of the mass was not resorted to while the smelting works were in operation, until a short time before they were abandoned; but when the ore from it was used the daily yield of iron, I am informed, was increased in the ordinary process of smelting from three and a half up to four and a half and five tons.[13]

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[12] "On the twenty-first lot of the ninth range of Bedford a bed of magnetic iron ore three or four feet in thickness occurs at or near the junction of the gneiss with the crystalline limestone. Deposits of this ore are also said to have been recently discovered on the sixth lot of the third range, and on Black lake in the eighth lot of the fourth range of the same township; but no details are yet known with regard to them." Geology of Canada, 1863, p. 674.

Ore deposit north of Crow lake.

"On the north side of Crow lake, about 300 yards from the shore, on the twelfth lot of the third concession of Marmora, magnetic oxide of iron occurs, thickly but irregularly disseminated in a pale green epidotic rock, similar to some portions of the rock of the Big Ore bed. At the time the Marmora works were last in operation an opening was made at this place which shows a breadth of twenty to thirty feet, all of which contains the ore, sometimes distributed in patches in the direction of the stratification, and sometimes in large irregularly shaped lumps and solid masses. The bed runs nearly east and west, apparently dipping south, and was readily traced for about 300 yards to a clearing, where it terminates in a sharp cliff. Such of the ore as was used at the works is represented to have proved of excellent quality, and to have added considerably to the daily yield of smelted metal; it seems to be peculiarly free from pyrites. The rock along the north shore of Crow lake is frequently of the pale green color and epidotic character which marks this ore bed, and has grains of magnetic iron diffused through the mass, from which circumstance it appears probable that the ore-bearing portion is continuous, although it may not in all places be equally productive. The course of this ore westward would at length carry it to an intersection or junction with the northwestward course of the Big Ore bed; and the dip of the one bed being south and the other northeast, it seems probable that they may prove to be different parts of the same bed on the opposite sides of a synclinal form.[14]

In Seymour.

"At Allan's mills, on the twenty-fifth lot of the twelfth concession of Seymour, where the dome of Laurentian rock protrudes through the fossiliferous limestone, magnetic iron ore is thickly disseminated in the rock over all the area exposed, which is about two or three acres. The rock on the left bank of the river appears to be a conglomerate of the Laurentian series, in which the presence of rounded forms supposed to be pebbles is perceptible on the smooth polished surfaces, where they display various colors; but these pebbles, when the mass is broken across, are so intimately blended with the matrix as to seem almost perfectly homogeneous with it; the iron ore in the conglomerate is disseminated only in small crystals and thin strings at wide intervals, but the succeeding rock, which seems to overlie it (the dip being to the southeast), and is a strong and tough mixture of whitish felspar with dark green pyroxene, yellowish-green epidote and occasional patches of red felspar, holds magnetic iron ore in considerable quantity. The breadth of the ore-bearing portion is at least thirty yards, and the run seems to be nearly parallel with the river; but although the distribution of the ore is pretty general, it scarcely appears to be in sufficient abundance, so far as may be judged from surface specimens, to be worked with advantage.

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[13] "Many years ago a blast furnace was erected at the village of Marmora for the purpose of smelting the ore from this deposit, and iron of a superior quality was manufactured. More recently different companies have for short periods made renewed attempts to smelt the ore with very satisfactory results so far as the quality of the metal was concerned. The distance of the place from a shipping port was however found a serious obstacle to success, and the furnace is for the present abandoned." Geology of Canada, 1863, p. 676. See also pp. 14-22 of this Report.

[14] "An opening which has been made here exposes a breadth of from twenty to thirty feet, through which the ore is irregularly disseminated in lumps and masses running with the stratification, which is nearly east and west, and apparently with a southward dip. The bed was traced for about 300 yards to a clearing, where it terminates in a sharp cliff." Geology of Canada, 1863, p. 675.

Indications of hematite and specular ores.

Delusive beliefs of the possession of mineral wealth.

"There are other places in Marmora and the adjoining townships where iron ore has been found, and some that have been partially worked, one of which was on the ninth lot of the eighth concession of Marmora, in which a fine-grained hematite in patches constitutes the ore. Near the ore bed are large loose masses of rock with dark red garnets in cavities or druses associated with pyroxene and calcspar. Specular oxide of iron is known to exist at some place near the Deer river, north of Belmont lake. I procured a few specimens of it from a person who had been diligently working the ore under the delusion that it contained from forty to sixty per cent. of silver. What the character of the vein or bed in which it occurs may be it is not in my power to say, as I did not succeed in finding the place, nor could I get any satisfactory account from those who had visited it. In almost all parts visited this year, but more especially in the back settlements, a great number of the inhabitants are possessed with the delusive belief that the precious metals abound among the rocky ridges of the Laurentian country, and that they by their own individual exertions are capable of realizing vast wealth. Iron pyrites, mica, plumbago, specular iron, galena and other bright or metallic substances are indiscriminately collected, barrelled and buried in the woods, with the full impression by those engaged in such business that they have stored away so much gold and silver; and although every second person met with had a specimen of some sort to present, with anxious enquiries as to its nature, hardly a single individual could be found who was willing to give the smallest information as to its locality. It was in vain to argue with such persons that the consequences of a proper examination might possibly be more advantageous to the common interest than anything they were likely to accomplish in secret and unassisted; such an argument was only regarded as the result of a governmental scheme to deprive them of their imagined wealth; and an appearance of anxiety to procure information only rendered their secrecy the more profound.

"The specular oxide of iron was seen during the season's examination in a few places, but in no one instance in anything like sufficient quantity to be of any economical importance."[15]

MACFARLANE'S REPORT ON THE HASTINGS DISTRICT.

A second report on the geology of the Hastings district was made by Thomas Macfarlane in 1865, when several locations reported upon by Mr. Murray were again examined, together with some others not previously known. Among the beds of magnetic iron ore which Mr. Macfarlane found to occur in large or apparently remunerative quantity are those on the following locations: Lot 3 in range 5 of Elzevir, 19 in 1, 11, 12 and 17 in 5, and 25 in 6 of Madoc, 13 in 3 and 6 in 9 of Marmora, and 7 and 8 in 1 of Belmont.

The Seymour bed.

Referring to the Seymour bed, Mr. Macfarlane says the strike of the ore is almost at right angles with the rock of the neighborhood, which perhaps is owing to the proximity of the granite. The overlying rock is chlorite slate, and chlorite also occurs intermixed with the ore. A great part of the ore is solid and free alike from rock and pyritous impurities. The same bed is supposed to continue through lots 9 and 10 in the sixth range, 8 in the seventh and eighth and 12 in the fourth, but no deposits of importance were found on these lots.

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[15] Geological Survey of Canada, 1852-3, pp 137-42.

On lot 19 in the first range of the same township a partially exposed bed was observed which had an apparent thickness of twenty-five feet, but it could not be accurately measured. The compass was found to be quite useless near it, varying very greatly from a due north line on approaching the deposit and as much as 90 degrees when immediately over it. The ore was stated to be in great part pure and solid, but some of it contained iron pyrites.

A cause of failure in smelting ore of the Big Ore bed.

Referring to the Big Ore bed of Belmont, Mr. Macfarlane observed that a very considerable part of the difficulty experienced in treating the ore from this mine at the Marmora furnaces must be attributed to the fact that no attempt was made at sorting it, in consequence of which it contained too large a proportion of pyrites. "The substance which principally forms the matrix of the ore is a pyroxenic greenstone, the nature of which was not all taken into consideration in the metallurgical treatment of the ore. It doubtless contained comparatively little silica, and required probably little or no limestone to flux it. On the other hand, its poverty in alumina would render the addition of clay or lime of much advantage in its treatment in the furnace." There were two principal openings at this mine about 250 feet apart, the dip in the most northerly, which is the principal one geologically, being 60° north-eastward, and in the other 80°.

The Marsh bed in Marmora.

The bed on lot 6 in the ninth range of Marmora, known as the Marsh ore bed, has the same strike as that of the Big Ore bed, namely, northwest and southeast, and the dip is 50° northeastward. Much of the ore was found to be pure and solid, but a large quantity of it was contaminated with iron and copper pyrites.

Hematite.

Several beds of hematite ore were also reported upon by Mr. Macfarlane as occurring in the townships of Madoc, Elzevir and Marmora, but none of them in large quantity.[16]

ARCHÆAN ROCKS OF EASTERN ONTARIO.

Mr. Vennor's reports on the region from Marmora lake to the Ottawa river.

The first detailed examination of the Archæan rocks in the eastern part of the Povince, and the economic minerals which they contain, was begun by Mr. Vennor in 1866 under the direction of Sir William Logan, and was continued for a period of ten years. The territory surveyed by Mr. Vennor extends in an easterly direction from Marmora lake through Hastings, Addington and Frontenac to the Rideau waters in the northwestern corner of Leeds, and thence northerly through Lanark and parts of Renfrew to Allumett island in the Ottawa river. The rocks lie in a series of troughs running with the course of the belt, and from the various reports made upon them it is apparent that their geological relations are not easily understood. In the earlier reports they were described as belonging to the Laurentian system. Mr. Vennor at first was disposed to classify them as Laurentian and Huronian, and subsequently as a new series to which the name Hastings was given. Other classifications of rocks were also made in the course of his work, especially in the county of Lanark; but in the final report, reviewing the whole field of exploration, the general conclusion arrived at was that they consisted of two divisions, the lower composed of gneiss and syenite and the upper of gneisses and crystalline limestones. The latter he described as occurring altogether upon the southern side of the belt, and dipping under the lower Silurian formations which cover the country southward to the St. Lawrence. Mr. Vennor was also of opinion, from his first year's observations in Hastings, that the magnetic iron ores were included in hornblendic and pyroxenic rocks which constituted the second of the three divisions into which the formations of Hastings and Addington were grouped; but examinations upon other parts of the field proved that this conclusion was not tenable. It follows therefore that the theory interwoven into the first extract which follows is not to be entertained. It may be indeed that the occurrence and origin of iron ores in this district must be studied anew before a theory can be adopted which would possess practical value for the explorer and the miner. Mr. Eugene Coste, who spent the seasons of 1884-5 in Hastings and the adjoining counties north and west of it, arrived at the conclusion (at variance with the views of Logan, Hunt, Harrington and Vennor) that both the iron ores and the apatite found in the Archæan rocks are of igneous or eruptive origin, which is important if true. But his report and geological map have not yet been issued, although their early publication was promised several years ago [17]

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[16] Geological Survey of Canada, 1863-6, pp. 97, 103.

In the report of 1866-9, after three years of work in the Hastings and Addington field, Mr. Vennor thus describes the occurrence of iron ores in the townships of Madoc, Marmora and Belmont—his three divisions of rocks, A, B and C, being premised:

Iron ores in Madoc, Marmora and Belmont.

"The deposits of iron ore in Madoc, Marmora and Belmont, which occur in the ferriferous band at the base of the greenish hornblendic and pyroxenic rocks, have been alluded to in several of the early annual reports of the survey; they have also been noticed in the General Report on the Geology of Canada for 1863, pp. 675 and 676, and again in greater detail in Mr Macfarlane's report for 1866. In these various reports however they have been described as separate local deposits, a sufficient number of facts not having then been accumulated to unite them in one continuous horizon. But having during the last three seasons, in accordance with your instructions, examined them more in detail with relation to the rocks in which they are enclosed, I have been able to satisfy myself that, with one or two unimportant exceptions, nearly all the deposits of magnetic oxide in the district will be found in the present division [B], being sometimes its only representative. As the deposits of iron ore already known in this zone are of economic importance, and as other yet undiscovered masses of a similar character may exist, I shall, with a view of aiding the search for them, here give a somewhat minute description of the course in which it appears to me they will be found to run.

The ores in a continuous horizon.

A belt of ore traced from the Seymour bed to the Big Ore bed.

"The Seymour ore bed is situated on the eleventh lot of the fifth range of Madoc, where the associated hornblendic and pyroxenic rocks, and certain chloritic slates there occuring, are well displayed. Their course from this lot is about S. 65° E. (mag.), and passing through the tenth and ninth lots of the sixth range, and the eighth and seventh of the seventh range, along which course the ore is almost continuous, it becomes partially covered up by the unconformable Lower Silurian limestone; but turning over the axis of an anticlinal it can be traced curving through the seventh, eighth and ninth lots, and part of the tenth in the eighth range, whence it strikes N. 65°-70° W. (mag.) through the tenth, eleventh and twelfth of the seventh range, and thence through the thirteenth, fourteenth and fifteenth of the fifth range. On the last named lot a deposit of magnetic ore occurs perhaps next in importance only to the Seymour bed, and it is worthy of note that its place here is exactly opposite to this bed and on the other side of the anticlinal mentioned, on the crown of which occurs a coarse red syenitic rock, (A 1) which has been before referred to. From the seventeenth lot of the fifth range the course of the iron-bearing rocks gradually tends westerly, and would appear to pass through the seventeenth and eighteenth lots of the fourth range, the eighteenth of the third and the eighteenth and nineteenth of the second and first ranges.

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[17] I learn from Dr. Selwyn that the delay has occurred through failure of Mr. Coste to furnish his report on the district. The map was printed several years ago, "but it has been reserved, daily expecting the report which ought to accompany it."

On these last named lots in the first range the ore is probably again in considerable quantity, but the traces of it occur only in loose masses in the soil, the ore in place being apparently at a considerable depth beneath the surface. From these lots the band runs into the township of Marmora, and, changing its direction, trends southward, keeping almost immediately to the east of the Moira river, the course of which might almost be said to denote its further run through this township. On the nineteenth and eighteenth lots of the eleventh range this iron zone is represented by rust-stained slates, holding some considerable beds of yellow sulphuret of iron with traces of magnetic iron ore, and here it is closely associated with a large mass of coarse white granular limestone. Thence it runs southward through the tenth, ninth and eighth lots of the ninth range, where the McCallum iron ore bed, mentioned in an early report, is situated; while farther southward its course is indicated on the sixth and seventh lots of the eighth range, by the occurrence of the Marsh ore bed. A short distance beyond these last lots the ferriferous belt must run under the main body of the Silurian limestone lying to the south and to the east, where it is lost sight of. But while thus covered it appears to change its course, and bearing westward emerges at Marmora village, where the green hornblendic and epidotic rocks are marked by traces of magnetic iron ore, and hold veins of red hematite. These rocks are seen running into Crow lake, under the waters of which, and under the adjoining unconformable overlying horizontal lower Silurian limestones, the greater part of the strata of this division are concealed. The north shore of the lake however gives evidence of the course of the belt in the Kean ore bed, which occurs on the thirteenth lot of the third range of Marmora, and in an exposure protruding through the Silurian limestone on the sixth lot of the first range of this township. The Big Ore bed, on the south shore and western extremity of the lake, in Belmont, belongs to the same belt, and is probably brought up on a third line of elevation to the westward.

"Northeastward through Belmont no very large exposures of the ore have yet been observed; but deposits may still be found between Crow and Belmont lakes, along the western shore of the latter, and up the valley of the Crow river, as well as on Deer lake, about the twenty-fifth, the twenty-sixth and twenty-seventh lots of the second and third ranges. The exposure at Allan's Mills, on the twenty-fifth lot of the twelfth concession of Seymour, noted by Mr. Murray in his report for 1852-53, has probably some relation to the turn which occurs in the course of the belt in Belmont lake, but whether united by a continuous outcrop, or separated on the opposite side of an anticlinal form, the overlying Silurian limestone prevents us from deciding.

Tracing the belt eastward from Seymour bed.

"Returning to the Seymour bed in Madoc, with the view of tracing this belt eastward, we find very few deposits of the ore of any extent. On the twelfth lot of the fourth range we have a small bed of magnetic iron ore, and again on the sixth lot of the third range, beyond which, southward, the belt runs under the Silurian. At the eastern end of Hog lake, on the Moira river at Downey's rapids, magnetic iron ore is again met with, and finally in Elzevir, on the third lot in the fifth concession, where it occurs in a bed from two to three feet thick enclosed in a steatitic material, as mentioned by Mr. Macfarlane in the report of 1866.

"Where the rocks of division B are brought up in the northwest quarter of Madoc magnetic iron ore has been found on the twenty-fifth lot of the sixth range of Madoc, where a small bed occurs dipping to the northeast at an angle of from forty to forty-five degrees. The only other locality is in the extension of the belt farther north, on the fifty-fifth lot on the west side of the Hastings road in Tudor, where it is associated with gneiss and granular limestone (A3 and A4). This last locality has not been mentioned in any of the previous published annual reports, but samples of the ore were sent by

A belt from Madoc northward into Tudor.

you to the London Industrial Exhibition of 1862. The ore would appear to be of excellent quality, although more or less mixed with graphite. The breadth of this bed could not be determined, owing to the wood-covered condition of the country, but from the large masses of ore scattered about in the vicinity there is little doubt that it occurs in abundance.

"It is probable that other beds of this ore will yet be found along the course of the rocks B, whose distribution has thus far been partially pointed out, and will be further understood from the description to be given of the next overlying division C, at the base of which this ferriferous belt occurs."

Working the Big Ore or Blairton mine.

Referring subsequently to the Belmont ore bed, Mr. Vennor states that in 1857 an American company was established for the purpose of working the property, and that after trials of several parts of the band the portion near the base was found to be of suitable purity for smelting. Three hundred men were employed in mining and sorting the ore that year, and towards the end of the season one hundred and fifty tons a day were carried by rail to Cobourg and there shipped to the American side where it was smelted at Pittsburgh. A few hundred yards southeast from the main work another excavation was made on what was called the Sandpit bed, from which a very pure ore was obtained. The ores raised from both mines were sorted into three grades, the two highest of which were selected for exportation, while the third was left on the ground for future disposal.[18]

Survey of Addington and Frontenac: classification of rocks.

In 1870 Mr. Vennor continued his survey eastward through portions of Addington and Frontenac, and while still classifying the rocks under the three divisions already referred to, he was able to summarise them briefly as follows, in ascending order:

A. Gneiss, fine, syenitic, with crystalline limestones and magnetic iron ores (Laurentian);

B. Diorites and diabases, passing into chlorite schists, often epidotic with steatite, and with magnetic and hematitic iron ores (probably Huronian);

C. Dolomites, argillaceous, calcareous and micaceous schists, with gneisses.

Here it will be observed that iron ores are found to occur in the first division, differing in this respect from the occurrence of those ores in the Hastings district, and indeed Mr. Vennor states that the second division afforded no iron ores in the region examined during the season of 1870; they were found closely associated with the limestones division.

Tracing a belt from Howse mine in Bedford to North Crosby, fifteen miles.

Besides other localities previously referred to, in which ores were found in the township of Bedford, was one known as the Howse iron mine on lot 4 in the first concession, where a bed of solid magnetic ore had been uncovered for about twenty-five yards across the strike. Fifty tons was raised from this mine in 1869 for shipment to Charlotte, N.Y., and the ore was found of good quality. In the following year 100 tons was mined and drawn to Westport on the Rideau. Northeastward of the Howse bed magnetic ore was again found on lot 6 in the third and lot 8 in the fourth concession of the same township. These localities are referred to by Sir William Logan in the report for 1858,[19] where it was conjectured that they would be found to continue to one on lot 21 in the ninth concession noted by Mr. Murray in his report for 1852-3. This supposition Mr. Vennor was enabled to verify having traced a zone of the iron-bearing rock from the Howse mine to lots 20 and 21 in the ninth concession of Bedford and thence northeastward to lot 19 in the eight concession of North Crosby at Spectacle lake, a distance of fifteen miles.

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[18] Geological Survey of Canada, 1866-9, pp. 150-2 and 161. Dr. Sterry Hunt in the same report, p. 258, states that much of the ore shipped from this mine to Pittsburg was found to be objectionable on account of the considerable proportion of sulphur which it contained, but that the Sand-pit bed yielded a much purer ore. Mr. J. L. Aunger of Blairton has sent me the following note under date of December 8 concerning the present condition of Blairton mine: "It is the most strange thing I know to see this mine, with its half-million tons or more of iron ore within three miles of the Canadian Pacific Railway lying idle, and parties passing it by going 40 miles or more from a railway looking for iron ore. If the same body of iron could be placed 40 miles in the woods where attention is given to seeking for minerals it would take well, and the first thing would be, 'Now then, for a railway to it.' I know what I am writing as to the quantity of ore in this mine, and don't fear to meet it in print."

[19] See p. 35 ante.

Allan's mine in North Crosby: the belt traced through South Sherbrooke and Bathurst.

A deposit of magnetic ore on lot 27 of the fourth concession of North Crosby seemed to Mr. Vennor to be a most valuable one, and it would appear to form the first of another series of similar deposits stretching northeastwardly through South Sherbrooke and Bathurst. The ore is a fine crystalline magnetite, and the openings showed the existence of a large amount. Explorations of the property were made in 1868 under direction of the owner, Hon. George W. Allan, and about 100 tons of ore was raised, but the untimely death of the miner in charge caused the work to be discontinued.[20]

Fournier and Bygrove mines, and other occurrences in Crosby and Bathurst.

On lot 14 of the first concession of North Crosby there is apparently a bed or belt of magnetic ore parallel to Mr. Allan's deposit, known as the Fournier mine, and on lot 3 of the same concession is the Bygrove mine. The latter had been opened during 1869 by Mr. George Oliver of Perth, who mined about 150 tons of a very fair quality of magnetic ore. Other occurrences of iron ores were found on lots 17, 18 and 19 in the third concession of this township bordering on Christie's lake, and again on the 10th and 11th lots in the eighth concession of Bathurst, which had been worked to some extent by a Perth company. On the last mentioned lots the magnetic ore was found to be much mixed with a fine crystalline green apatite.

The Dalhousie mine.

On the east half of lot 1 in the fourth concession of Dalhousie a valuable deposit of hematite ore was opened in 1866 and was worked for several years. The bed is described by Mr. Vennor as averaging seven feet in width in a band of crystalline limestone, and dipping at an angle of 45° to the southeastward. Six shafts of eight by ten feet and varying from 20 to 68 feet in depth had been sunk by November, 1871, and about 10,000 tons of ore was raised. The ore was drawn to Perth, a distance of twelve miles, in summer at $1.75 per long ton, and in winter at $1 ; from there it was taken by rail to Brockville and thence shipped to Cleveland, where it was laid down at a cost of $5 per ton. The ore was claimed to average 60 per cent. of iron, according to numerous analyses made in the United States, but six determinations in Canada afforded an average of 57 per cent., with about .025 phosphorus.[21]

Shipments from the Chaffey and Yankee mines.

In a note upon the Chaffey mine in South Crosby to which reference has already been made, Mr. Vennor found in 1871 that two excavations had been made to a depth of thirty feet in a solid bed of magnetic iron ore, and during that year, with twelve men employed, 3,500 tons of ore was raised and shipped to Cleveland via Kingston. At the mine this was worth $2.25 per ton, and delivered at Cleveland it brought from $6 to $6.50 per ton. The cost of carriage to Kingston, a distance of 44 miles over the Rideau canal, was 75 cents per ton. About one hundred rods north-northeast from the Chaffey mine, and on a continuation of the same bed, is the Yankee or Matthews mine, upon which work was commenced in 1860. The opening made here had a depth of 40 feet in 1871, during which year fifteen men were employed, 4,000 tons of ore was mined, and 3,300 tons sold and shipped to Cleveland, where the price obtained was the same as for ore of the Chaffey mine. The total amount of ore sold and shipped to Cleveland from these two mines for the two years 1870 and 1871 amounted to 14,520 tons.

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[20] In a letter received from Senator Allan that gentleman says: "Unfortunately the person I employed, a Mr. Otey, was taken suddenly ill and died without making any full report as to the nature and extent of the deposit. Since then I have not taken any steps to have the property further developed. Iron mining except in a few places had gone down. My property labored under the disadvantage of being five miles from water communication at Newport, and at that time there was no railway passing near it, and so I have allowed it to remain, being satisfied that whenever iron mining revived and was carried on extensively my property would come into play." In the Report of 1866-9 Sterry Hunt gave an analysis of the ore, showing it to contain 64.9 metallic iron, 1.03 titanic acid, 1.33 alumina, .82 lime, .84 magnesia, .007 phosphorus, .120 sulphur, traces of oxide of manganese, and 5.25 insoluble matter, chiefly quartz, with a little black mica and green pyroxene. Dr. Hunt says: "This is a very fine and valuable ore, and the deposit would seem to be worthy of careful examination."

[21] Geological Survey of Canada 1870-1, pp. 312-4 ; also do. 1871-2, p. 122. "The production from February, 1872, to the end of February, 1873, was forwarded to Perth at $1 per ton, in loads which averaged three and three-quarter tons; thence to the Rideau canal at 60 cents ; thence to Kingston at $1.25 to $1.50, and thence to Cleveland at from $1 to $1.50. The total production from 1870 to 1873 has been rather over 11,100 tons. The wages of the hands employed have varied from 80 to 90 cents. per day, with board."—Vennor's Report for 1872-3, p. 177.

Referring to the quality of ores from these and other mines in the locality, Mr. Vennor made the following notes in his report:

Quality of iron ores in the district.

"Samples of ore from the Chaffey, Yankee, Bygrove, Fournier and Foley mines were, in accordance with your instructions, submitted to Dr. B. J. Harrington for analysis. The following figures show his determination of the percentage of metallic iron in these ores, but more time will be required for their complete examination:

Chaffey mine	52.91	per cent.	metallic iron.
Yankee mine	52.09	"	"
Bygrove mine	59.55	"	"
Fournier mine	59.59	"	"
Foley mine	58.69	"	"

"The ores from the Chaffey, Yankee and Foley mines were all found to be titaniferous. That of the Chaffey mine is stated by Dr. Hunt to contain 9.80 per cent. of titanic acid. Dr. Harrington finds 12.32 per cent. of titanic acid in the ore from the Yankee mine, and also a large amount of sulphur, which renders it altogether an inferior ore. The ore from the Foley mine contains only 2.68 per cent. of titanic acid, which is not a sufficient amount to detract from its value. The Chaffey and Yankee ores were also examined for phosphorus, but neither of them was found to contain a weighable amount. The Bygrove and Fournier ores are free from titanium, and I think it extremely probable that they will be found to belong to beds somewhat higher in the series than the titaniferous ores."[22]

Titaniferous ores.

Other explorations in this region during the season of 1872 appear to have convinced Mr. Vennor that the iron ores were only to be found in connection with crystalline limestones. Magnetic iron ore was reported to exist in the gneiss area of Frontenac, in the townships of Kennebec, Clarendon and Palmerston, but Mr. Vennor found them only in grains or in connection with dykes, and nowhere in sufficient quantity to be of economic importance. The entire absence of crystalline limestones in this section he mentioned as a fact worthy of note, and although it might be premature to say positively that all the available deposits of magnetic or other ores of iron occur and are to be sought for in proximity to such limestones, still the accumulation of evidence over a great extent of country examined would appear to point in this direction.[23]

Iron ores found in association with crystalline limestone bands.

During the season therefore the bands of crystalline limestone were by him made a special object of investigation; first, because they presented characters which enabled them to be much more easily followed than any of the intervening gneiss bands; and, secondly, because that with them, or in close proximity to them, are deposits of iron ore and apatite in economic quantities. Cross sections of the country were made through the townships of Oso, Olden and Bedford, as well as through South Sherbrooke, in which six distinct bands of limestone were observed having a southeastward dip varying from 28° to 60° and running for the most part in east and west lines, but after being traced a distance of 20 or 25 miles eastward they were

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[22] Geological Survey of Canada, 1871-2, p. 123.

[23] Geological Survey of Canada, 1872-3, p. 149.

Magnetic ore in the higher limestone bands.

found to curve in a northeasterly direction ; and in relation to these bands of limestone the attempt was made to assign the geological horizon of the iron ores. The occurrence of ores, Mr. Vennor observes, appears on lines which bear a certain relation to the occurrence of some of the bands of limestone and form distinct horizons which can be followed and in which other deposits of iron may be sought for. Immediately above the sixth and highest of those bands magnetic iron ore occurs in South Sherbrooke in two places, viz., at the Bygrove mine on the third lot of the first concession, and at the Fournier mine on the fourteenth of the same range, as well as in other places on the same horizon to the eastward through Bathurst and to the southwestward through Bedford. At the base of the fifth band ore occurs along the northern shore of Christie's lake in the same township, in the eighteenth, nineteenth and twentieth lots of the third concession, at what was then known as the Watson mine. Immediately below the fourth band ore was found at the Foley mine on the tenth lot of the eighth concession of Bathurst, whence it could be traced through the eleventh, twelfth and fourteenth lots of the same concession. Here for the first time apatite was found in considerable deposits closely associated and in some instances intermixed with the iron ore. In the third, second and first bands of limestone no magnetic ore had been met with by Mr. Vennor, although at the base of each of these rust-colored strata occur ; yet he observes as worthy of note that the great bed of hematite in Dalhousie township upon which is situated the Dalhousie mine is found between the first and second limestone bands, and the general conclusion is thus stated : "From the foregoing it will be seen that in the section of country so far examined by me magnetic iron ore has been found only in connection with the three highest bands of limestone, while in the other bands it is represented by only rust-colored beds of gneiss and quartzite."[24]

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[24] Geological Survey of Canada, 1872-3, pp. 159-162. In the report for 1873-4 Mr. Vennor appears to have doubted the occurrence of the sixth band of limestone. Of the fourth and fifth he gives the following description, pp. 105-6 :

"The Crow lake, Rock lake and Silver lake band of limestone is well marked and important. It is separated from the last by a great volume of granitic gneiss, which is probably not less than eight to nine thousand feet thick. From Eagle lake, in the northeastern corner of the township of Hinchinbrooke, it has been traced to the head of Crow lake, in Oso ; thence northeastward to Rock lake, a small lake situated close to the townline of South Sherbrooke. Entering this last township, it runs through portions of the fifth and sixth concessions, passing a little to the north of Silver lake, and enters the sixth concession of Bathurst, whence, again trending northeastwardly, it passes through the seventh concession to the eighth concession line, which it follows, in a nearly direct course, to Balderson's Corners on the line between Bathurst and Drummond townships. In Drummond it immediately runs under a heavy drift, and shortly after is capped by rocks of Lower Silurian age. The distance from Eagle lake to Balderson's Corners is about twenty-six miles. A remarkable feature of this band is that it immediately overlies a zone of rock containing magnetic iron ore and deposits of phosphate of lime. These minerals were observed in proximity to this limestone at Eagle lake, at Crow lake, in Bedford and Oso, and again at the Foley and McVeigh lots in Bathurst, in which last locality both have been mined to a small extent. The limestone has also interstratified with it a number of subordinate bands of red felspathic bands, which separate the whole into a number of unequal parts. The largest calcareous bed does not exceed 150 feet, but the total thickness from the base of the lowest bed of limestone to the top of the highest may be estimated at not less than 2,600 feet. The limestone is coarsely crystalline, and holds in abundance small scales of a yellowish-brown mica, and less frequently graphite.

"The Bob's lake, Tay river and Meyers lake is perhaps the most important band in the whole sequence. It is separated from the last by a great volume of gneissic strata, which has a transverse measurement of over 13,000 feet. This may or may not represent the actual thickness of the gneiss, as the strata are all in a nearly vertical attitude, and there is no evidence of any repetition of the beds. The limestone was continuously traced from the southern extremity of White lake in Bedford, across Green bay and Bob's lake, to the Tay river in South Sherbrooke, and thence along the general bearing of this river to and across Meyers or Christie's lake into the township of Bathurst, where its course is shortly concealed by heavy drift. The distance from White lake in Bedford to the last position in which the band was noted in Bathurst is about twenty-two miles. The thickness cannot be less than 2,600 feet, and the limestone differs in a marked manner from either of the four inferior bands. It resembles them in being white, but is much more coarsely crystalline. Graphite is abundantly disseminated through it in brilliant plates or scales, and there are also layers of white quartzo-felspathic rock associated with it, which occur both in the form of interstratified beds and irregular masses. This may, for the present, be considered as the

The following account is given by Mr. Vennor of the Watson mine at Christie's lake:

Watson mine at Christie's lake, South Sherbrooke.

"This location is situated on the eighteenth, nineteenth and twentieth lots of the third concession of South Sherbrooke, and embraces an area of 259 acres; the openings made are on the first and last numbered lots. On a high bluff on the north shore of the lake, on lot eighteen, three beds of iron ore have been uncovered and to some extent worked during the last summer. The strata, which here consist of dark grayish and greenish hornblendic gneiss, dip to the southward at angles varying from 15° to 80°. The uppermost bed of ore, and the nearest to the lake, has been uncovered for about thirty-five feet in length by twenty-four in breadth, and a considerable mass of ore has been exposed. No walls have yet been reached, and I think it is probable that the uncovering has been extended on the face of the bed rather than across its outcrop. In the second and underlying bed a breadth of eighteen feet of ore has been uncovered, and can be traced by openings made on its course for a distance of upwards of 150 feet. In the third and lowest bed a well defined foot wall of gneiss has been struck, and a solid mass of ore is exposed measuring eighteen feet in width. The extreme distance between the openings on this property on the strike of the ore beds is nearly one mile, and the distance between the top of the upper and the bottom of the lower bed of ore is about 300 yards. Several hundred tons of ore have been taken out, but operations have been chiefly confined to the determination of the extent of the deposits, which is now pretty satisfactorily known. An experimental shipment of the ore has been made to Cleveland, and it is reported to have given perfect satisfaction to the smelters, and it has further been ascertained that this ore will produce a quality of iron well suited for the manufacture of Bessemer steel. An analysis made by Dr. Harrington of a sample of the ore which I brought from this location gave as follows:

Metallic iron	65.62 per cent.
Titanic acid	2.83 "
Phosphoric acid	0.05 "
Sulphur	Not determined.

"It may be further stated that the facilities for mining here are favorable; the position of the ore on a high hill affords easy and cheap drainage, and a ready means of disposing of the *debris*, and these mines can probably be worked for a considerable time before resorting to expensive underground operations."[25]

Further explorations in Frontenac and Lanark.

More careful explorations of the counties of Frontenac and Lanark were made by Mr. Vennor during the season of 1874, and a number of newly discovered or until that time little known mining locations were noticed by him in the report of his work during that year. Several of these are deserving of mention. In the vicinity of Eagle lake, in the northeastern corner of the township of Hinchinbrooke and along the westerly boundary of Bedford, iron ore was found in several localities, principally on the twenty-sixth, twenty-seventh and twenty-eighth lots of the first concessions of both townships, but chiefly on the twenty-ninth and thirtieth lots of Bedford, near the lake shore. The magnetite occurs there in a bedded form associated with heavy, dark hornblendic and dioritic rocks, which in a number of instances are met with in close connection with the ores of iron in this section of country. Fair exposures of ore have been made at several places, but the beds are extremely

In Hinchinbrooke and Bedford townships.

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highest band of limestone in the series, and it belongs to the synclinal forms which I have yet to bring under your notice as occurring in Bedford and Loughboro'. It is overlaid by a considerable volume of gneissic strata in which there also occurs a small band of limestone—the Farren lake band—as noticed (Report of Progress, 1872-3, p. 160) but which may be left out of consideration for the present. At its base, and also at some distance above it, there are important deposits of magnetic iron ore, a fact which has already been dwelt upon in my previous reports."

[25] Geological Survey of Canada, 1872-3, p. 174.

irregular. The ore itself is described as a beautifully crystalline magnetite, yeilding according to Professor Chapman's analysis 62.52 per cent. of metallic iron. It also contains traces of phosphorus, a very small amount of sulphur and about 3.23 per cent. of titanic acid. One serious drawback however exists in the fact that apatite is associated with much of the magnetite, both in the form of grains and crystals. The crystals are easily separated from the ore, but the finely disseminated granular portions are so intimately intermingled as to be inseparable. A similar association of magnetite and apatite exists at the Foley mine in Bathurst, and appears to characterise the lowest horizon of iron ore deposits. Mr. Vennor mentions, in proof of the stratigraphical arrangement of the ores, that the position of the Eagle lake deposit in relation to the overlying band of limestone is the same as that of the Foley mine, and this band of limestone having been continuously traced from one locality to the other, a line may be drawn which will in all probability show the course along which other masses of iron ore may be expected to occur. Another characteristic of the iron ore of this horizon is that it is generally of a coarsely crystalline character, it being found both at the Foley mine and at Eagle lake in large octahedral crystals, the axes of which are often more than an inch in length, but the occurrence of these crystals would in itself be no proof of the deposit being a vein. "At Eagle lake," Mr. Vennor says, "the magnetite seems to occur as an unmistakable bed, and between the Foley and Eagle lake mines it is found in several localities in disseminated grains and strings in a peculiar stratified dioritic rock which is apparently made up of the same constituents as the more coarsely crystalline diorites, with no traces of stratification. These coarse varieties of diorite occur as lenticular or irregular shaped masses at perhaps two or more horizons, and they are often unaccompanied by iron ore." It is observed that most of the diorites are undoubtedly interstratified masses. In Hastings they are fine-grained, as is also the magnetite, while in Frontenac and Lanark, where the diorites are coarsely crystalline, the accompanying magnetites are of the same description.

Coarsely crystalline magnetic ore.

Silver lake and Christie's lake ores, in South Sherbrooke

Another location of iron ores is in the vicinity of Silver lake in South Sherbrooke, where they were discovered during the summer of 1873. These, upon careful examination, were found on an extension of the iron ore beds of the northern shore of Christie's lake. They occur on lots 13, 14 and 15 of the fourth concession of South Sherbrooke, and openings made upon them showed the strike of the bed to be about northeast and southwest, with a steep dip to the southeastward. The ore is of much the same character as at Christie's lake, and is a compact, bluish-black magnetite containing about 64 per cent. of metallic iron and less than 2 per cent. of titanic acid. The following analyses show the close comparison between the ores of the two localities :

	Silver lake.	Christie's lake.
Magnetic oxide of iron	88.59	90.61
Titanic acid	1.75	2.33
Insoluble residue	5.75	0.05
Metallic iron	64.15	65.62

Tracing the Wolf lake deposit in Bedford.

Reference has already been made to a deposit of magnetic ore on lot 21 of the ninth concession of Bedford, near Wolf lake.[26] This location was carefully examined by Mr. Vennor with the dip needle, and he had reason to suppose that ore existed in considerable quantity. "The bed or beds of ore here," he says, "are undoubtedly on the course of the ferriferous horizon upon which is situated the Hon. G. W. Allan's deposit in North Crosby, and form an outcrop upon the opposite side of the synclinal which exists between these deposits and the Fournier and Bygrove mines. Other exposures of magnetic iron ore, near Wolf lake, on 24 or 25 of the tenth concession, are probably on the run of those on lot 21 of the ninth concession of Bedford. The two localities are fully one mile and a quarter apart, and it is more than probable that further discoveries will be made in the intervening country."

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[26] Ante pp. 35 and 43.

Spectacle lake deposits in North Crosby.

A mile to the eastward of Wolf lake, on 18 and 19 of the eighth concesion of North Crosby, are the Spectacle lake deposits. The ore occurs in diorite and appears to exist in considerable quantity, but it contains many impurities. The property was worked at one time by an American company, but after one shipment the enterprise was abandoned. Mr. Vennor observes that the position of the deposit at a considerable altitude in what has been termed the Westport mountains is against its future prospects.

Ore beds south of Christie's lake.

The beds of ore on the south side of Christie's lake are quite distinct from those already noted as occurring on the northern shore, being in a much higher horizon, although lower than the Fournier and Bygrove ores. They occur between the road and the lake on lots 17 and 18 of the eighth concession of South Sherbrooke, and are immediately beneath the highest or Farren's lake band of limestone. The ore is said to be of an excellent quality, resembling that of the Fournier and Bygrove mines, but it does not appear to exist in quantity.

The other deposits in this region referred to by Mr. Vennor are those known as Mitchell's and Gordon's, the former in the rear of North Crosby and the latter near the town line between South Sherbrooke and Bathurst, but little was known respecting their extent or quality. The following particulars are given of four of the more important deposits or mines in this district :

Vennor

In the township of Bedford.

"*Howse Iron Deposit.* This is one of a series of outcrops of iron ore which occur at intervals from the fourth lot of the first concession to the eight and ninth lots of the fourth concession of Bedford. These have been known for a great number of years, and specimens of the ore were obtained by the surveyors when laying out the township upwards of sixty years ago. But excepting the little work done on the Howse lot (lot four, concession one), during the years 1869 and 1870 (see Report of Progress, 1870-1, p. 312), the deposits have up to the present time remained as they were originally found. The shipment of fifty tons of ore from the Howse deposit, in the year 1869, to Charlotte, N.Y., as far as I have been able to learn, was attended with satisfactory results, at least as regarded the quality of the ore ; but the long carriage, seventeen miles, over sandy and very hilly country to Westport village, on the Rideau, before it could be shipped to Kingston, proved a decided obstacle to the enterprise. The ores at the surface are not as pure as many of those in South Sherbrooke, and are more mixed with rock matter ; still this is in a great measure compensated for by their nearness to the Kingston and Pembroke Railway. For it will be remembered that the very impure iron ores of the Chaffey mine, near Newboro on the Rideau, have been mined for years successfully, merely in consequence of their being upon navigable waters, although the ore besides containing 9.80 per cent. of titanic acid, only averages about 50 per cent. of metallic iron. The Howse deposit is of an exceedingly irregular character, and it would be a difficult matter to draw any definite outline that might be said to represent the shape of the mass of ore. The greatest length however is on the strike of the bed, namely, nearly northeast and southwest, and at one place the breadth appeared to be from fifteen to twenty paces. Through this last distance however there are several *horses* of rock. Beyond these facts I can state nothing respecting this deposit. That there is visible a great quanitity of ore is undoubted, and as it can be mined in the cheapest manner, namely, by open cuttings, there seems no reason why it should not be profitably worked. The position of this and the adjoining beds of iron ore is almost immediately beneath the Wolf lake, Crosby lake and Pike lake band of limestone, which is the southeastern

Vennor.

outcrop of the Bob's lake, Tay river and Meyers lake band, on the opposite side of a synclinal form. (See Report of Progress, 1873-4 p. 104). Consequently these ores are in the same stratigraphical position as those represented by the Meyers lake and Silver lake deposits. This fact of the occurrence of outcrops of iron ore in the same stratigraphical positions, on both sides of a synclinal form, is, I think, sufficient proof of the continuity of the ore, not only in length but also in depth The occurrence of strongly rust-colored gneisses in many parts of the Bedford basin or synclinal, between Bob's and Potspoon lakes, convinced me that this ferriferous horizon is brought, or almost brought, to the surface by undulations in several places between the two divergent outcrops of ore. It also seems to me highly improbable that the iron ore should have only been deposited to the limited extent seen along the two outcrops of the same horizon of rock.

In the township of North Crosby.

" *Allan's Iron Ore Deposit.* This deposit of magnetite occurs on the twenty-seventh lot of the fourth concession of North Crosby. It is close to the town line of South Sherbrooke, and a little over half a mile southeastward of the Fournier mine. Nothing whatever has been done here since the autumn of 1868, and the excavation then made by the Hon. G. W. Allan is filled with water and *debris.* The question therefore as to the extent of the deposit yet remains undecided ; but as the surface indications are promising and the ore of good quality it is altogether probable that mining might be carried on with profit for some time. The route to the Kingston and Pembroke railway is the same as that from the Meyers and Silver lake deposits, viz : *via* the Tay river and Bob's lake, and from the Allan deposit to the Tay river the distance is about two miles. For the purpose of reference and comparison I append a partial analysis of this ore, taken from the table of analyses, Report of Progress, 1873-4 :

Magnetic oxide of iron	90.14=metallic iron, 65.27
Phosphorous	0.07
Titanic acid	1.03
Insoluble matter	5.25

The iron ore occurring on lot 27 of the seventh concession of North Crosby undoubtedly belongs to this horizon, but the distance between the two outcrops is about two and three-quarter miles.

In the township of South Sherbrooke.

" *Bygrove and Fournier Deposits.* Both of these deposits of magnetite occur in the first concession of South Sherbrooke and are in the same horizon. The Bygrove mine on the third lot has remained unworked since the year 1869, when it was to some extent worked by Mr. George Oliver of Perth. The Fournier deposit on the fourteenth lot however has from time to time been more or less mined. During the summer of 1873 the last attempt at raising this ore for the market was made. A shaft was sunk to the depth of one hundred and ten feet, and the company raised in all about 600 tons of good ore. At this depth however the deposit became very irregular and uncertain, and as the ore could not be extracted without the removal of much rock work was abandoned and has not been resumed since. I may here mention a fact respecting this iron horizon that is not generally known, namely, that at a short distance from the Fournier mine, on the fourteenth lot, the ferriferous belt passes beneath Farren's lake in the second concession, its strike changing and coinciding with the course of the lake. On its exit from the lake at its western end the zone again becomes clearly marked by the presence of iron, until on the third lot of the first concession we arrive at the deposit of ore constituting the Bygrove mine. Specimens of ore from these two deposits gave about an equal percentage of metallic iron, the Fournier yielding to analysis 59.59 per cent. and the Bygrove 59.55 per cent. In the Report in which these analyses were first given (Report of Progress 1871-2, p. 123) I further stated that the Bygrove and Fournier ores were free from titanium, and that it appeared extremely probable that they would be found to belong to beds 'somewhat higher in the series than the titaniferous ores.' This supposition has since been clearly proved. They have been found to lie in the highest iron-bearing horizon and immediately below the highest band of crystalline limestone. The second or underlying belt is that on which are situated the Meyers and Silver lake deposits, the ore from which as we have seen contains from 64 to 65 per cent. of metallic iron and invariably a small percentage of titanic acid; whilst in the next or third underlying belt represented by the McVeigh, Foley and Eagle lake deposits, the ore is more titaniferous, and is further characterized by its peculiar coarsely crystalline character and by the presence of apatite or phosphate of lime.

Vennor.

"I have thus I think with some degree of certainty succeeded in establishing the existence of three distinct horizons of iron ore, each of which possesses some peculiar characteristics by which it may be again recognized. Should such prove to be the case it will be a most important step gained, and an invaluable aid to future predictions respecting the iron ores of the Laurentian rocks."[27]

Three horizons of ore established.

In the prosecution of the work of the Geological Survey on the Quebec side of the Ottawa river, Mr. Vennor was enabled to make some interesting comparisons between the occurrence of iron ores in the Ontario and Quebec districts. In the Report for 1876-7 he observed that the iron ore horizons marked by several iron mines in Hull and Templeton are in precisely the same relative stratigraphical position as the ore horizons of South Sherbrooke and North Crosby, as illustrated by the Silver lake, Christie's lake, Fournier and Allan mines. These horizons are beneath the true apatite-bearing rocks, although a few deposits of apatite have been found occasionally associated with and beneath them. One feature in connection with the iron ore deposits in the Ottawa section is deserving of mention, namely, the intermixture and interstratification of hematite with magnetite. In no one instance, Mr. Vennor says, does this condition occur in the corresponding iron horizons in South Sherbrooke or North Crosby, where the ore is invariably a crystalline magnetite. Hematite frequently occurs in Lanark county, both below and above the magnetic ore horizons, but always by itself or in association with apatite and pyrites. The distance between the South Sherbrooke and Hull deposits is about fifty-six miles in a direct line, and although no other important deposits of ore intervene this is mainly owing to the fact that most of the intermediate country is occupied by the flat-lying rocks of the Lower Silurian formation, which entirely conceal the lower crystalline rocks. The fact however that iron ore occurs in workable quantity in Hull township immediately where the crystalline limestones and gneisses first again become well exposed, gives, in the opinion of Mr. Vennor, considerable encouragement to those interested in this ore respecting its permanency in certain horizons of rock. "It must be borne in mind," he says, "that iron ore though often in all appearance a clearly interstratified mass is not a continuous deposit. It may occur at intervals for many miles in a section of country, and yet between the exposures of ore there may not be the slightest indication of its existence. Most of the large deposits of iron ore in eastern Ontario and in Ottawa county are exceptional occurrences, and their unusual extent is due to the recurrence of the outcrops of ore on anticlinal and on synclinal folds of the strata. For example the Big Ore bed in Belmont exhibits an anticlinal and synclinal fold; the Seymour ore bed in Madoc is a decided synclinal, in which two outcrops of iron ore each fifteen feet in thickness are sharply folded the one upon the other; while the great Hull iron ore bed consists of an anticlinal of magnetic ore through which breaks an inferior band of crystalline limestone. So often indeed is the importance of an iron ore deposit due to one or other of these forms that I have for some time been in the

Comparisons of occurrence of iron ores in Ontario and Quebec.

Relation of ore deposits to rock foldings and dislocations.

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[27] Geological Survey of Canada 1874-5, pp. 112-22.

habit of directing prospectors to such points as those in which the strata folded over or under the axis of an anticlinal or synclinal, and so far many of the trials made at these points have been successful. Dislocations of the strata, or faults with their accompanying dykes and lodes, have also much to do with some of the larger deposits of iron ore."[28]

HARRINGTON'S REPORT ON THE IRON ORES OF CANADA.

A valuable report on the iron ores of the Dominion was made by Dr. Harrington of the Geological Survey in 1874, and published in the report of the Survey for that year. A summary of this report, in so far as it concerns the Province of Ontario, is presented below:

Origin of iron ores: chemical and mechanical concentration.

Referring to the origin of the iron ores, Dr. Harrington states that from the Laurentian days down to the present processes of chemical and mechanical concentration have been in operation which have resulted in the formation of beds and veins of ore. The processes have doubtless, he thinks, differed in kind to a certain extent, and they have operated under more or less favorable conditions; and subsequently to their deposition the ores have frequently been subjected to agencies which have deprived them of their original nature, so that it is not surprising to find them differing widely in chemical composition and physical characters. Three classes of ores are treated of in the report, viz., (1) anhydrous oxides, embracing magnetic iron ore or magnetite, hematite, including crystalline and earthy varieties, and titanic iron ore; (2) hydrous oxides, including limonite or brown hematite, and bog ore; and (3) carbonates, including spathic ore and clay ironstone. The last-named ore, it may be observed, has not yet been discovered in the older parts of Ontario, but a large bed of it has been noticed by Dr. Bell on the Mattagami river near latitude 50° 30′ north and longitude 82° west. The most important deposits of magnetic iron ore occur in rocks of Laurentian and Huronian age, but it is also found in rocks which have been referred to the Lower and Upper Silurian, as well as in the Devonian and Trias.

Veins and beds of magnetic ore.

There are few opportunities for studying the character of the Laurentian and Huronian magnetites in our country as compared with those afforded in Norway and Sweden, and also in New York and New Jersey; but Dr. Harrington observes that while the larger and more important deposits such as Big Ore bed in Belmont are interstratified beds, true veins of magnetic iron ore also occur. Thus at the Foley mine in Bedford the country rock, which is a diorite showing little or no indication of bedding, is cut not only by the deposits of magnetite but also by veins of coarsely crystalline calcite, the two minerals being in some instances associated. In the undoubted beds the magnetite is generally granular or massive, but does not occur in large crystals of definite form. In New Jersey the workable deposits of magnetic ores are regarded as of sedimentary origin, though formerly believed to be eruptive. "The latter view was also taken by Sir Roderick Murchison as to the origin of some of the rich deposits of magnetite in the Urals, and many of the deposits of magnetite in Norway and Sweden have been considered as eruptive by Durocher and others. None of the Canadian magnetites, so far as I am aware, have ever been regarded as eruptive, at least by the officers of the Geological Survey." It will be found hereafter that this opinion has been held by at least one officer of the Survey.

Sedimentary magnetites.

On the origin of our sedimentary magnetites the question arises as to whether they were deposited as such, or in some other form and afterwards altered to magnetite. In some cases beds may have been formed by the accumulation of iron sands, as they are forming in the gulf of St. Lawrence today, the material being derived from the disintegration of pre-existing crystalline rocks, in which case they might be expected to contain not only magnetite but ilmenite ; but Dr. Harrington thinks it probable that in general their origin has been similar to that of the modern bog and rock ores.

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[28] Geological Survey of Canada, 1876-7, pp. 297.

Harrington.

Conversion of bog ore into magnetite.

" Deposits of magnetite as a rule do not continue of uniform thickness for any great distance like the enclosing rocks, and this is just what might be expected if we suppose them to have originally occurred as bog or lake ores which accumulated in local hollows or depressions. No ore moreover would be more readily converted into magnetite than bog ore, on account of the considerable proportion of organic matter which the latter contains. In this connection may be described a very simple but interesting experiment tried with a specimen of bog ore from L'Islet containing about 22 per cent. of water and organic matter. The pulverized ore was placed in a platinum crucible and heated for an hour at a temperature of 190° F. At the end of that time it had parted with its combined water, or at any rate with sufficient to cause the color to change from brown to bright red. It still however retained organic matter, and on heating for a few minutes in a tightly closed crucible and at a temperature considerably below redness a reduction of the peroxide ensued and a black, strongly magnetic powder was obtained, apparently consisting of magnetic oxide and not of metallic iron, as it occasioned no precipitation of metallic copper in a solution of the sulphate. The cover was now removed from the crucible and a red heat given, when in a short time the powder again became red, or rather purplish-red, and non-magnetic. Finally the heat was raised a little higher (to bright redness), and soon the powder became black and strongly magnetic, having apparently parted with a portion of its oxygen. These changes are instructive, for while brought about in the laboratory they might take place in nature. They show too that in some cases magnetites may have been formed from such ores as bog ore at comparatively low temperatures, the reduction being due to the organic matter of the ore. That a magnetic oxide should be converted into a non-magnetic oxide, as described above, is a curious fact. It is generally stated also that peroxide of iron requires a white heat to convert it into magnetic oxide, but the heat of an ordinary Bunsen burner has been found to readily convert limonites, even when free from organic matter, into magnetic oxide."[29]

Variations of occurrence.

At the Hull mines on the east side of the Ottawa river the magnetite occurs in crystalline limestone containing graphite, mica and pyroxene, but the latter more rarely. At the Big Ore bed in Belmont the ore is interstratified with diabase, greenish epidotic and chloritic rocks and crystalline limestone. At the Seymour bed in Madoc the ore is underlaid by a thin band of soft mica schist, and overlaid by reddish-gray highly felspathic rocks, in places porphyritic, and occasionally passing into syenite or syenitic gneiss. At the Chaffey mine the ore occurs in coarsely crystalline gneiss containing both mica and hornblende, the gneiss adjoining a band of crystalline limestone. On the Quinze river in northern Ontario, Mr. McOuat found magnetic iron ore interstratified with quartzite, the ore forming layers from the thickness of paper to about an inch, and interlaminated with similar layers of whitish-gray and dull red fine-grained quartzite. Here the iron ore constitutes probably from a fourth to a third of the whole, and as the thickness of the whole band is about thirty feet the total thickness of the layers of iron would probably be not less than eight feet. Dr. Harrington observes that some of the Michigan ores occur in an analogous manner, and are considered to be of Huronian age. Concerning the occurrence of iron ore in beds of diorite, as at the Foley mine, he says it is quite impossible to distinguish the rock from diorites of igneous origin, saving that it appears in general to follow the sinuosities of the beds on either side of it, and is sometimes seen to blend into hornblendic and micaceous schists. But the term "diorite" strictly speaking belongs to an igneous rock, and there seems to be no good name for a similar aggregate of a sedimentary origin. In Hastings and Addington, as well as elsewhere in Ontario, fine-grained diorites occur, but those which are associated with magnetic iron ore in the townships of Bathurst and South Sherbrooke in Lanark are generally coarse-grained, and often contain scales of dark-brown mica, grains of magnetic iron ore and small quantities of quartz. These observations illustrate the variable character of the rocks adjoining deposits of magnetite in our old crystalline series, but while it is exceptional to find such deposits in limestone they frequently occur near the junction of other rocks with it. "This fact should always be kept in mind in tracing or searching for magnetites, as the limestone bands are continuous and constant in character for long distances."

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[29] It is the opinion of Messrs N. H. and H. V. Winchell of the Minnesota Geological Survey that similar changes have taken place in the iron ores of the Vermilion schists in that state in the same way, but upon a grand scale. "Magnetite," they say, "differs from hematite in having a greater ratio of iron to oxygen, and in its crystalline system. Magnetite is found in the primary eruptive basalts, where it is one of the essential characteristic minerals. By greater oxidation it is converted to hematite, which is frequent in the metamorphic rocks. When magnetite is found in the metamorphosed rocks it is generally at points and planes of contact with eruptive dykes whose pressure, heat and percolating hot solutions have concentrated the iron from surrounding rock masses. When it constitutes ores in the metamorphic rocks, as in the Vermilion series of schists, it is disseminated either as an ingredient of a massive basic rock, or it is interlaminated with siliceous sheets which are similar to those of 'chalcedonic' quartz in the jaspelite of the Keewatin schists. Structurally it repeats the characters of magnetite in the eruptive gabbro on the one hand, and of the hematites of the Keewatin on the other. It is necessary to consider therefore only the laminated condition, since the massive deposits can be referred directly to dynamic and thermal agents. These laminated deposits of magnetite are embraced sometimes in undoubtedly eruptive basic rock. The change therefore from hematite to magnetite through the action of heat and moisture seems to be one of the common phenomena of metamorphism." It is of the same general character as the authors' show to have taken place in other minerals of the Keewatin schists, viz.: "a step back toward the condition which the constituent iron molecules had when they were erupted with basic lava from the interior of the earth." (The Iron Ores of Minnesota, 1891, p. 21.) The iron ores found in the Vermilion series of rocks in Minnesota are magnetites, whereas by far the larger part of ores in the Mesabi range are hematites ; but in his paper on the Mesabi Iron Range (1892) H. V. Winchell shows that in the eastern portion of it, near Gunflint lake on the Ontario boundary, the ore is magnetite and "probably owes its magnetic properties to the heat of the gabbro overflow upon the hematites which were deposited in the rocks at the time of their formation in the oceanic waters."

A fact worth noting by explorers.

Following is a table of analyses of magnetites given by Dr. Harrington, the first four of which were made by Dr. Hunt and the fifth and sixth by Prof. Chapman.

Analyses of Ontario magnetites.

	I.	II.	III.	IV.	V.	VI.
Peroxide of iron....	69.77	90.14	72.80	89.22	58.35	59.39
Protoxide of iron....	....	....	....	....	24.87	26.93
Oxide of manganese....	....	traces	....	none	0.13	traces
Alumina	5.65	1.33	....	....	0.42	0.67
Lime..................	....	0.82	1.69	none	1.43	0.33
Magnesia	4.50	0.84	6.86	....	2.56	0.82
Phosphorus	0.085	0.007	0.035	0.012	0.07	traces
Sulphur	1.52	0.12	0.027	0.073	0.04	0.07
Carbonic acid....	....	....	1.50	....	....	....
Silica	7.10	....	....	....	11.17	....
Titanic acid	9.80	1.03	....	....	0.73	3.23
Graphite	....	....	....	....	....	....
Water	2.45	....	3.50	....	....	....
Insoluble matter.. ...	....	5.25	14.73	10.42	....	8.38*
Totals.............	100.875	99.537	101.142	99.77	99.77	99.82
Metallic iron..........	50.52	65.27	52.72	64.61	60.19	62.52

*Silica and insoluble rock matter.

In this table the first column represents the Chaffey mine in South Crosby, the second Hon. George W. Allan's mine in North Crosby, the third the

Sand-pit bed of Belmont at Blairton, the fourth the Seymour mine in Madoc, the fifth the deposit on lot 20 in the first concession of Snowdon, and the sixth a deposit on lot 29 in the first concession of Bedford.

Varieties of hematite ores.

Harrington.

Occurrence of hematite.

Under the name of hematites are included several varieties of ore consisting of the anhydrous peroxide of iron; crystalline varieties with metallic lustre are either specular or micaceous; while the earthy varieties, often containing clay, are known as red ochre, and between the crystalline and the ochrous ores comes red hematite. As a rule hematite is freer from impurities than magnetite. It is not so easily reduced as hydrated oxides or carbonates, and is liable to produce gray rather than white iron, a fact of importance in connection with the manufacture of Bessemer pig. "Hematite occurs in both beds and veins, the beds generally, though not always, being the more important deposits. Like magnetite it is not found solely in any one kind of rock, but often in rocks of most diverse characters. A few examples illustrative of this fact may be of interest. Beginning with the Laurentian, we find at the McNab mine near Arnprior a compact red hematite occurring in crystalline limestone. The bed is inclined at a high angle and has been worked to a depth of about eighty feet, when it is said to have thinned out. At the Dalhousie mine, twelve miles from Perth, a compact red hematite somewhat similar to the McNab ore also occurs in limestone, although at one point in the workings a soft chloritic looking slate with numerous crystals of pyrites seems to intervene between the ore and the underlying limestone. The limestone is highly crystalline; that underlying the main deposit being white and containing large quantities of tremolite, while that which overlies it is stained red with peroxide of iron. When the mine was opened up there appeared to be two beds cropping out in places at the surface with four or five feet of limestone between them. The uppermost and smaller of these was found to run out at a few feet in depth, and to extend but a short distance in the direction of the strike. The larger deposit was in places as much as nine feet thick at the surface, and at a depth of eighty feet had an average thickness of four or five feet. Among other examples of the occurrence of hematite in Laurentian limestone may be mentioned the thin vein of specular ore on lot two, range four of Elzevir (Geology of Canada, 1866, p. 101), and the finely-granular hematite of Iron island, lake Nipissing." No important deposits of hematite have yet been discovered in our Huronian rocks, like those of Michigan, but where they have been found they are very similar in the mode of occurrence, consisting for the most part of alternate layers of compact hematite or specular ore and quartzite or jasper, in dioritic or diabasic rocks. In the following table are given analyses of several ores from different mines in Ontario:

	I.	II.	III.	IV.
Peroxide of iron	84.42	84.10	82.25	86.80
Protoxide of manganese	......	......	......	......
Alumina	......	......	......	......
Lime	3.02	4.93	trace	none
Magnesia	0.50	......	......	......
Phosphoric acid	0.03*	......	0.026*	trace
Sulphur	0.065	......	......	0.092
Carbonic acid	2.93	3.87	......	......
Silica	......	4.00	......	......
Titanic acid	......	......	......	......
Graphite	......	......	......	......
Water	......	......	0.66	......
Insoluble matter	7.160	......	16.05	12.75
Totals	98.125	96.90	98.986	99.642
Metallic iron	59.09	58.80	57.60	60.76

*Phosphorus.

The first is from the McNab mine near Arnprior, the second from the same locality, the third from the Dalhousie mine, and the fourth from Gros Cap on lake Superior.

Workings of Ontario mines.

Referring to the production of several mines in Ontario, Dr. Harrington says the Blairton or Big Ore bed of Belmont was in 1872-3 the largest in the country, the output for that fiscal year amounting to nearly 30,000 tons. In July of 1873 ore was shipped to Pittsburgh at the rate of 300 to 400 tons a day. The Yankee and Chaffey mines together had for several years been producing between 7,000 and 8,000 tons, and were the demand for titaniferous ores greater the production of these two mines could readily be increased. From the Dalhousie mine 3,000 to 4,000 tons had been annually raised and shipped for several years, but although the ore was one of the finest in the country the work had recently been stopped at this mine owing to the dulness of the market. Several hundred tons of very fine ore had also been taken out of the Fournier mine in South Sherbrooke during the winter of 1872-3.[30]

COSTE'S VIEWS ON OCCURRENCE OF ORES IN ARCHÆAN ROCKS.

Report on the Madoc and Marmora region.

Reference has been made to the views of Mr. Eugene Coste on the mode of occurrence of iron ores in the Archæan rocks, differing essentially from the views of other officers of the Geological Survey. Mr. Coste's report on the Madoc and Marmora region, in which he proposed to treat in detail of the metamorphosed primitive rocks and "to establish and explain the nature and relations of the deposits of iron ore and of the auriferous mispickel and quartz veins, with the granitic and dioritic igneous masses,"[31] has not yet been published; but the following extract from the report of 1887-8 presents a summary of his conclusions:

Coste.

"The object of this paper is to present in a concise form the conclusions arrived at by the writer as to the mode of occurrence of the iron ores and phosphate deposits in the Archæan rocks of Canada after a careful and minute study of many of these deposits in the iron and phosphate districts of Ontario* and in the counties of Ottawa and Pontiac in Quebec. It is here presented on account of the practical bearing that it may have on the future developments of these important deposits, as it is hoped that it will be found to be a strong encouragement for the working of many of these deposits in depth as well as a guide in the following of their irregular structure and a help in the further discovery of new deposits of these minerals. We think we may say that our conclusions will be found to be greatly at variance with the views generally admitted here in Canada, expressions of which have been published principally in the different reports of the Geological Survey, and especially in the Geology of Canada, 1863, and in the well-known subsequent reports of Dr. Hunt, Dr. Harrington and H. G. Vennor. For indeed we believe that we have gathered year after year strong and clear evidence to show that not only our deposits of iron ores in the Archæan rocks are of an eruptive or igneous origin, but also that our deposits of phosphate are exactly similar and have also the same origin. This is why we are treating here of the deposits of these two minerals together as we believe that they are exactly analogous, and that which can be said for one is applicable to the other. As far as the iron ores are concerned, the view of their deposits in the Archæan rocks being of an eruptive origin is far from being a new one, and has been held by a great many eminent geologists in many countries, principally I believe in France, Norway and Sweden, and also by some of the English and American geologists. In the case of the phosphate (apatite) the

Eruptive origin of iron ores and phosphate in the Archæan rocks.

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[30] Geological Survey of Canada, 1873-4, pp. 192-259.

[31] Geological Survey of Canada 1886, p. 20A.

*Counties of Haliburton, Victoria, Peterborough, Hastings, Frontenac, Leeds, Lanark and Renfrew.

Coste.

eruptive or igneous origin has also been advanced in Norway and in France, but by a smaller number of observers, probably on account of the fact that the apatite deposits are not so numerous as those of iron ores, and thus the opportunities for examination and report were less frequent. Here in Canada this eruptive origin of the apatite as well as of the iron ores has always been denied so far; and if my conclusions were not backed by so many facts, some of which were only brought to light in the workings of the mines in the last few years, I would feel somewhat reluctant to go thus entirely against the views already arrived at in this country by several very able men, but these facts were repeatedly observed and have been very carefully ascertained. The principal among these observed points are the following:

Observation of facts to support the theory of eruptive or igneous origin.

"1. About thirty different deposits of iron ores (principally magnetite, though sometimes hematite) have been geologically surveyed by us* in the Madoc and Marmora region of Ontario, and were found to occur in the form of irregular veins around and always in close proximity to a large granite mass, or to dykes and bosses of granite derived from it. The granite intrusions clearly cut across the Archæan crystalline limestone and schists, and the deposits of iron ores are also manifestly veins cutting in a like manner across the Archæan rocks.

"2. Away from the main granitic bodies, in the region covered by the map above referred to, there are no large deposits of iron ore, and when small quantities occur there can be seen almost in every case a small dyke of granite along the iron ore; so that the intimate connection of the two cannot be doubted.

"3. An exactly similar connection was also observed between the iron ore deposits and intrusive igneous masses in a more extended region of several thousand square miles, also geologically surveyed by us,† and comprising parts of the counties of Hastings, Peterborough and Victoria, in Ontario. There the iron ore deposits such as those forming the Blairton mine, Orton mine, Baker mine, Emily mine, Coe Hill mine, Jenkins mine, the Snowdon mines, etc., were always found to be intimately connected in the manner described above with many varied kinds of igneous rock, such as granite, granulite, pegmatite, mica syenite, hornblende syenite, diorites and diabases.

"4. In the region north of Kingston, in the counties of Frontenac, Leeds, Lanark, Renfrew, Pontiac and Ottawa, many deposits of iron ores and many deposits of phosphate were observed also in the same association with igneous rocks, and both cutting through the Archæan rocks. In the case of the phosphate the igneous rock was often the rock termed by Dr. Hunt 'pyroxenite,' but at other times it was a pegmatite or a mica syenite or a pyroxene syenite. In that region the iron ore and the phosphate have been found in the same deposits, as witnessed by the evidence at the Foley mine, the Forsyth mine, and especially at the Blessington mines, where the writer observed the apatite and the magnetite together in the workings of nine different pits, and where at the time of his examination last summer there were between 500 and 600 tons of iron ore and about 1,500 tons of phosphate on the dumps, the two minerals having been taken out from the same pits.

"5. In the two regions mentioned above, the apatite and magnetite were often seen to be amongst the component elements of these masses or dykes of

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*This map on the scale of forty chains to one inch, and comprising an area of one hundred and twenty-five square miles, is now in the hands of the engraver and is expected to be ready shortly. It will be accompanied by a report in which the details of our observations will be given at length.

†A map of about 3,500 square miles covering this region has been prepared and is expected to be published at the scale of four miles to the inch in the course of a year or so.

Coste.

igneous rocks, which rocks were observed to accompany these minerals in their deposits as a veinstone of quartz or calcite carries other minerals in other veins.

The ore deposits consequently of deep-seated origin.

"Considering all this, and knowing that similar facts have also been observed in other countries, especially in the states of New York and New Jersey, and in Norway and Sweden, it is only natural that we should conclude, like many other geologists have done before in those countries, that the iron ore and phosphate to be found in our Archæan rocks are the result of emanations which have accompanied or immediately followed the intrusions through these rocks of many varied kinds of igneous rocks which are no doubt the equivalent of the volcanic rocks of to-day. These deposits then are of a deep-seated origin, and consequently the fears entertained principally by our phosphate miners that their deposits are mere surface pockets, are not well founded. These fears are no doubt partly the result of the belief which has been somewhat prevalent that the apatite in them was the metamorphic equivalent of the phosphate nodules of younger formations, and it may be also that they have resulted from the fact that the apatite is irregularly distributed in these deposits and is often suddenly replaced by rock; this is not so often the case in the iron ore deposits which are on a larger scale. But notwithstanding this, when the deposits are properly understood to be, as we hold they are, igneous dykes and veins accompanying the igneous rocks, it will be easily seen why in the deposit itself the economic minerals can be suddenly replaced by rocks which may be said to be nothing else but the gangue. If this origin is understood it will besides facilitate and encourage the working of these deposits in depth, because the accompanying igneous rock forming a mass or a dyke alongside the deposit will be easy to follow, and, because if it is apatite or iron-bearing at the surface, it will always be a guarantee that it will also be in depth, as each separate mass of igneous rock is generally quite constant in composition."[32]

IRON MINES IN EASTERN ONTARIO.

Iron mines along the Kingston and Pembroke Railway.

The construction of the Kingston and Pembroke Railway had for one of its chief objects the affording of facilities to open up and work some of the iron ore deposits in the counties of Frontenac and Lanark, to which reference has been made in the foregoing pages. The deposits in the region of this railway are usually found in belts running in a northeast and southwest direction, parallel with the strike of the formations. The largest deposits are almost always found where the limestone and granite, gneiss or syenite come into contact, and this is largely true also of the iron ores in districts north and northwest of lake Superior. Magnetic ore is the principal variety, but specular ore has been discovered in several localities. Mr. William Rattle, an American mining engineer, who explored the district a few years ago, stated to the Mining Commission that he had found specular ore in several localities on a range in Darling. In one place he was shown a vein of magnetite 35 feet in width, and in another a bed of hematite at least 15 feet in width which he had traced 200 feet. Messrs. Bawden, Folger and Grady gave particulars to the Commission of the working of various mines along the line of the railway, of which the following is a brief summary:

Glendower mine.

The Glendower mine in Bedford is four miles east of the railway line, and is connected with it by a branch built in 1884. A large plant was erected and work was carried on upon an extensive scale for four or five years. The ore is magnetic, and runs from 50 to 60 per cent. of metallic iron. Near the surface it was clean and of fine quality, but at a depth of 120 or 130 feet it was found to contain sulphur, and operations were discontinued. At the bottom of the shaft the vein was 20 to 40 feet wide, the ore averaged 60 per cent. and the mine was in a position for raising 400 to 500 tons per day. Two or three other openings were made in the same locality, and numerous deposits are known to exist there. A bed of red hematite on lot 2 in the seventh concession has a width of 40 feet.

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[32] Geological survey of Canada, 1887-8, pp. 62-4s.

Mississippi mine.

North of the Mississippi river several locations have been worked in the township of Lavant. From one of these, the Mississippi mine, between 30,000 and 40,000 tons were taken out and shipped to Pennsylvania.

Wilbur mine.

The Wilbur mine in Palmerston lies between two bands of crystalline limestone, and about 100,000 tons of ore was taken out of the several shafts on the property. It was free from sulphur and phosphorus, and averaged about 50 per cent. of metallic iron, some analyses going up to 68 per cent.

At Calabogie lake.

Near Calabogie lake two shafts have been sunk and considerable quantities of ore have been raised, but it is said to have too much phosphorus for Bessemer iron.

The drop in the price of iron ore in United States markets which occurred while these mines were being opened led to the closing of the works, and scarcely any attempt has since been made to prove new locations or even to prospect for ore.

Iron ores on the line of the Central Ontario Railway.

In the county of Hastings the Central Ontario Railway was built at a cost of $2,000,000 to connect iron locations in the northern part of that county with lake navigation at Trenton. A large deposit of magnetic ore at Coe Hill in Wollaston was opened and worked for some time, as related in the statement of Mr. Ritchie, but for reasons mentioned by Mr. Ritchie operations were discontinued there. Prospectors report the existence of numerous and large deposits of ore in localities near to this line of railway and northward of its terminus, but no work has been done upon them to prove their extent or quality.

Belmont Bessemer Co.'s mine in Belmont.

A promising show of magnetic ore occurs on lot nineteen in the first concession of Belmont, the property of Mr. Ledyard of Toronto. It was leased in 1891 to the Belmont Bessemer Ore Co., and a railway is being constructed to the property. The deposit is said to range from 20 to 150 feet in width, and test borings have been made to depths ranging from 30 to 100 feet. The superintendent, Mr. Woodworth, informs me that little work was done last year owing to the depressed condition of the ore market, but numerous samples have been analyzed. The average of twenty-three samples made for the company gives the following result :

Metallic iron	65. 333
Phosphorus	. 016
Sulphur	.0747
Silica	4. 303
Titanium	. 743

This includes a lot of 100 tons sent to the Cambria Iron Co. of Pennsylvania, which gave 61.08 iron, .0225 phosphorus, .497 sulphur and 7.84 silica. A fifty-foot drift has been driven from a shaft at a depth of 40 feet, partly in ore and partly in what seems to be the foot wall. The mine is provided with steam boiler pumps, drill, hoist and suitable buildings, and can be put into good condition for shipping ore as soon as the railway is completed. This road is 9½ miles in length, and connects with the Central Ontario Railway two miles south of Marmora village. A further account of this mine is given in the statement of Mr. Ledyard, made to the Bureau as follows :

Ledyard.

"I am a dealer in mines, more particularly iron, and have been engaged in the business for twenty years more or less. I own the Belmont mine, which is leased to the Belmont Bessemer Ore Company of New York. They are not actually working the property at present ; but they have done sufficient development work to warrant them in building a railway into it, and they say they expect to have this railway completed next spring. So far as the

The Belmont mine.

Ledyard.

Extent and quality of the ore.

extent of the deposit of ore is concerned the development which I did on the property showed a needle attraction of 600 feet in length by about 400 feet in width in some places; the company claim to have found a considerably greater length. I sank prospecting pits; the company have put down shafts; they have one 50 feet in depth which showed ore all the way. They have had diamond drilling done to a depth of about 100 feet. At 90 feet in No. 1 drill hole the ore was wonderfully pure, running very high in iron and almost absolutely free from impurities—not a sign of sulphur. The ore was particularly good at 90 feet, but it varied as all magnetic deposits do in its mixture with rock. This company propose to work the property and export the ore to furnaces in Pennsylvania. They have their buildings erected and all their hoisting machinery and other plant prepared to go to work. Within a month's time they could probably have the railway finished and be at work if the market warranted. The low price of ore has kept them back, otherwise they would have been at work last year. The analysis of this ore shows it to be very similar to the Lake Angeline and Pittsburgh Mining Company's ore, which is the very highest grade. This ore comes from Marquette district, in the state of Michigan. Both myself and the company have had analyses of the ore made. Following are some of these:

Analyses.

Assayer.	Locality.	Iron.	Phos.	Sulph.	Silica.	Tit. Ac.
Molin	East Pit	70.326	.0056	.0023	.875	.000
“	North “	55.240	.019	.0000	11.200	.000
“	South “	60.376	.037	.007	.000	.000
“	Shaft No. 1	63.131	.023	.004	.000	.000
Scranton	No. 1	65.36	.005	.000	4.50	.000
Cambria	N. & S. Pit	68.83	.008	.000	1.96	.06
“	“	69.99	.012	.000	3.10	.15
S. of S., Toronto	Surface	64.26	.000	.040	.000	.000
Fisher	South Pit	68.88	.006	.000	3.18	.000
“	East Pit	69.85	.013	.012	.000	.000
Ledoux	Var. places	66.55	.013	.096	2.43	.000
“	No. 3 Pit	69.85	.013	.012	.000	.000
“	No. 2 Pit	68.33	.016	.037	.000	.000
Molin	East Pit	69.630	.003	.005	....	.000
“	No Pit	62.667	.013	.384	....	.000
....	Drain Hole 1, 75ft	60.376	.004	.002	....	.083
....	“ 70ft	65.104	.005	.074	3.83	.004
Pa. Steel Co	100-765 sample	68.930	.007	.000	4.12	....
Cambria Iron Co	100 tons	60.401	.022	.497	....	....
“	“	61.76	.023	....	7.84	....
Molin	....	67.309	.007	.130	....	....
“	....	69.630	.007	.158	....	....
“	....	71.951	.003	.041	....	....

“A number of analyses have been made by Mr. Molin of 20 Liberty street, New York, a well known Swedish expert. He has an article in the Engineering and Mining Journal of November 19th, 1892, in which he gives his opinion of this ore. The average of the samples he analyzed shows metallic iron 65.1 per cent., phosphorus .005, sulphur .074, titanic acid .04. The company state that an ordinary analysis shows no titanium at all, and that it is only by a very delicate test that it can be detected. The ore is a remarkably soft, fine ore. You will see what Mr. Molin says as to the suitability of the ore for making not ordinary Bessemer, but the very finest grades of steel. The phosphorus, as you will observe, is only .005 per cent. This property is in Peterborough, immediately adjoining Hastings county, hardly seven miles from Marmora village.

Iron ore properties in Snowdon.

“I have also some iron properties in the township of Snowdon, in Haliburton, consisting of lots 25 and 27 and 30 and 31 in the fourth concession. These I have developed by sinking shafts on them to some extent. Lot 26 belongs to Mr. Howland, and the Howland mine is situated on it. There are one or two other places in that neighborhood which show promising signs of ore, but it is doubtful if it is present in large quantity. There is also the Paxton mine in Lutterworth, out of which about 1,000 tons of beautiful ore was taken. This is in the section of country with which I am most familiar. Experts say that the formation in Snowdon is just the right formation for iron ore in quantity, and that from what they can see there is sufficient ore there to warrant mining on an extensive scale.

Ledyard.

Howland and Paxton mines.

"I should think a smelting furnace in Toronto could very profitably use these ores, but hematite would be required to mix with them. It is not quite so clear where the supply of hematite could be got. I found some in Belmont, which looks promising, but there has not been sufficient development to prove the quantity ; it is just south of the magnetic deposit which the Belmont Bessemer Company is working."

Extensive ranges of magnetic ore extend from the township of Snowdon in an easterly direction across Haliburton, Hastings and Addington into Frontenac. Mr. Pusey, whose statement is given below, describes the ranges as running parallel to each other at an average distance of ten miles, and at intervals the ore occurs in large bodies and generally of good quality ; but in one locality where the mass is very great it bears a high per cent. of titanium. In an interview Mr. Pusey gave the following information to the Bureau :

Iron belts extending from Haliburton to Frontenac.

"I am manager of the Bancroft Iron Company ; we are building a railway from a point near Kinmount on the Victoria branch of the Midland Railway eastward through the townships of Snowdon, Glamorgan, Monmouth, Cardiff, Faraday and Dungannon. East of the last named township we have not yet located the line, but explorations have been made recently which prove that large and rich bodies of ore exist in Barrie, Clarendon and Frontenac. Our object in building this road is to develop the mineral interests in that section of the Province. We have ten miles completed and in operation, and ten miles more ready for laying the rails, which will be put down early in the spring. The road leads to some very valuable iron deposits in the townships of Glamorgan and Monmouth ; the iron ore there occurs in two distinct ranges running in a northeast and southwest direction, which at their western ends are about ten miles apart, but approach each other and are almost merged into one range in the township of Dungannon in the county of Hastings. There is more crystalline limestone found in the southern range than in the northern one ; in the latter there is more of a red syenite. The ores of the north range are much richer than those of the south range, but both are magnetic. There is very little hematite or indication of hematite in the north range, but indications of this variety of ore exist on the south range. Outcroppings of ore are found along both ranges ; there are barren stretches and then numerous deposits of ore, seemingly clustered. So far as we have explored the north range it appears to be about one mile in width, but the width varies ; we have never explored north of a certain line, the line forming the southern boundary of the nine townships belonging to the Canada Land and Emigration Company. The south range will vary from five to ten miles in width. You will find the same class of ore over five miles south of our deposits, but we have never explored very much south of say a mile in width through that section. We have found outcroppings of ore at frequent intervals on both ranges through the townships of Glamorgan, Monmouth, Cardiff, Faraday and Dungannon, a total distance of say fifty miles. We have explored by sinking test pits or shafts at seven or eight different points on the north range within the fifty miles. We have found the ore to be very rich ; all the analyses show 70 per cent., not varying more

Pusey.

Construction of a railway to open up iron ore locations.

A double belt 50 miles long.

Pusey.

than one per cent. in any case. Following are analyses of three samples of ore from the north range :

Analyses of ores in north range.

—	1	2	3
Sesquioxide of iron	67.14	67.27	
Protoxide of iron	30.06	30.08	
Phosphorus....................	faint trace .	trace.	faint trace .
Sulphur	trace.	trace.	
Titanium	none.	none.	
Rock matter..................	2.74	2.58	
Metallic iron......	70.38	70.50	69.77

Deposit No. 1 is on lot 27 in concession 15 of Glamorgan. Deposit No. 2 is in the eastern part of Monmouth ; I do not know the number of the lot, but the two are ten miles apart and are taken from the solid lode, no float pieces. Deposit No. 3 was analyzed for iron and phosphorus only, and is situated twenty miles further east than No. 2. We have other deposits of similar ore in the north range ; there is one situated between the extreme east and No. 2 in the township of Cardiff, containing 68.27 of metallic iron. Following are analyses of samples from the south range :

Analyses of ores in south range.

—	1	2	3
Metallic iron.................	59.5	60.00	45.82
Phosphorus...................		.02	.02
Sulphur.............	.05	Trace.	

Victoria, Howland and Imperial mines.

No. 1 belongs to Mr. Shortiss and his associates, and is known as the Victoria mine. It was worked by our company at one time. The average ore would run from 58 to 61 per cent. ; but there was some as low as 48 and 50. No. 2, known as the Howland mine, is situated east of the Victoria mine in Snowdon township. There is one peculiarity about it which would apply almost as well to the Victoria mine, viz., the large amount of lime, 4.12 per cent., which it carries. It has also 2.72 of magnesia and .30 of alumina. All the sesubstances come in for fluxing, and answer very well for that purpose. The Imperial mine, No. 3, is also situated in the township of Snowdon. It yields a low grade ore, but one very free from impurities. I call it a hematite mine, but I think it will turn out to be more of a specular iron than a hematite.

Pine Lake mine.

"I think I should say a word about a very large deposit of titanic iron ore on lot 35 in the fourth concession of Glamorgan, known as Pine Lake mine. It has been explored by test pits at many different points which show a solid ledge half a mile in length by 100 to 200 feet in width. It forms a high ridge, and at one point crossed by a ravine there is an exposure of ore to a depth of 80 feet. It is a magnetic ore, containing 53½ per cent. of metallic iron, .017 of phosphorus and about 10 of titanium. This excess of titanium makes the ore useless according to present furnace practice, but recent experiments give good reason for hope that the titanium difficulty can be overcome with suitable flux. And it is well known that titanium in iron is not in itself objectionable ; on the contrary, it adds to the strength and ductility of iron. The Pine Lake mine however is the only one in the two parallel ranges of fifty miles in length which shows titanium in hurtful quantity. There is also only one mine in these ranges in which

Pusey.

phosphorus is in excess of the Bessemar limit. Where ore is shown to exist at so many points along the two ranges, and visible by outcroppings in large quantity, I think there need be no fear for the supply."

ORES IN NORTHERN ONTARIO.

Iron ores in the region north of the great lakes.

The principal area of the Archæan rocks of the Province is in the region north of the great lakes, lying between Ottawa river on the east and Lake-of-the-Woods on the west. There is good reason for believing that this territory is rich in minerals, and many valuable discoveries have already been made in it, although on account of its great extent it has been but very imperfectly explored. Iron ore has been discovered in numerous localities, east and west, but mostly in association with the Huronian rocks, and some of the deposits are known to be very large, and the quality of the ore is claimed to be very good. During recent years however there has been no inducement to explore the country for iron, and little progress has been made in our knowledge of its occurrence, saving in two or three localities beyond lake Superior.

Specular ore in lake Nipissing.

Iron island in lake Nipissing is composed of crystalline limestone interstratified with and cut across by trap. Small masses of specular iron ore, Mr. Murray stated in his report for 1854, are common to most of the rock in this island, but in the crystalline limestone there is a large display of it. For a breadth of about forty yards along the cliff on the east side the rock yields masses of ore of various sizes, sometimes in strings of an inch thick or upwards, and at other times in huge blocks of half a ton weight. The beach near this outcrop is strewed with masses of all sizes from several hundred pounds to small rounded pebbles not larger than marbles. Crystalline limestone also crops out on the west side of the island, which appears to correspond with that holding the iron ore on the east. The same minerals are found disseminated through the rock and strewed upon the beach. At the southwest point of the island the rock is again limestone, and a long beach running out from it to the westward is covered with boulders of specular iron ore. Iron ore also occurs at the southeast of the island, but not in such great abundance, and only in detached masses strewed upon the beach.[33]

Specular ore in the La Cloche mountains.

Wallace mine location.

In the report of the survey for 1848-9 Mr. Alexander Murray refers to the discovery of a vein of specular iron ore in the La Cloche mountains along the north shore of Georgian bay, on the Wallace mine location, "cutting the strata in a north and south direction with a width of 15 feet." Specimens of the ore from this vein were presented to Mr. Murray by Mr. Bristol, but he states that he had not an opportunity of visiting the locality. On analysis by Dr. Sterry Hunt the ore was found to contain 68.6 per cent. of metallic iron. The lode, Mr. Murray says, would yield 20 tons of metallic iron per cubic fathom, or at a breadth of 12 feet 40 tons for every fathom forward by a fathom vertical.[34]

It is shown by more recent examination however that the vein is not so large as was reported to Mr. Murray. The report of the Mining Commission describes it as consisting of about 8 feet of banded ore and quartzite, the ore varying from crystalline to compact specular. "The bed or vein may be traced some 200 or 300 yards westward and is about two feet in width where last visible." Eastward it is covered by a mass of *debris.* Mr. Thomas Frood, who is part owner of the location, described the ore as of steel color, slightly magnetic, and part of it as red and very soft. "The vein is visible for about 200 yards ; at the west end on the face it is about six inches wide ;

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[33] Geological Survey of Canada, 1853-6, p. 123.

[34] Geological Survey of Canada, 1848-9 p. 45.

at the east end where the pit has been sunk, the width of the vein is about 8 feet. The depth of the pit is about 20 feet and the vein seems to increase in width and the ore to improve in quality as we go down.[35]

Other occurrences.

South of the Wallace mine location and three miles northwest of Killarney, on a peninsula of grayish Huronian quartzite, Dr. Bell says there is a promising deposit of magnetic ore.[36] Explorers also report a fine occurrence of iron ore from this peninsula westward towards La Cloche island and eastward into the township of Rutherford.

Specular ore near Echo lake.

In describing the geology of the Huronian formation in the vicinity of Echo lake, Mr. Murray states that specular iron ore was frequently observed both in the trap and in the sedimentary portion of the formation, occasionally arranged in thin, continuous layers between the strata for considerable distances, and at other times in small isolated masses irregularly distributed through the rock. The latter condition, he states, was especially observed in the quartzose conglomerates with blood-red jaspers, where indeed the iron ore appeared to constitute a characteristic mineral.[37] Mr. R. E. Baily described to the Mining Commission a deposit of specular ore which he had discovered about three and a half miles northeast of Echo lake, and which had a width of 15 or 20 feet. Openings had been made upon it at six or seven places by which it had been traced for about 1,400 feet. The ore was shown by analysis to contain 65 per cent. of metallic iron, and to be very free from phosphorus and sulphur. Other discoveries are also reported in the same region.

A hematite mine at Desert lake, in Coffin.

In the township of Coffin James Stobie developed a location in 1874, and worked it three or four years. The width of the vein, Mr. Stobie stated to the Mining Commission, was from two to eleven feet, and the ore could be traced for a length of two miles. It was a hematite ore of good quality, and for three seasons it was shipped to Detroit. The location is at Desert lake, ten miles northwest of Bruce mines.[38]

On the east coast of lake Superior.

In 1865 Mr. Macfarlane made an exploration of the east shore of lake Superior, where the formations are largely the same as in the northern peninsula of Michigan. He observes that as the great beds of red hematite which occur at Marquette belong to the Huronian series of rocks, it ought to be matter for congratulation that the same ore has been found to characterize the same rocks on the Canadian shore. Discoveries of hematite had been made at Batchawana bay and Gros Cap, and "although neither of these so far as yet opened can compare in richness with the Marquette deposits, it cannot be doubted that future explorations, if vigorously pursued, will quickly develop iron mines on the north shore equally remunerative as those on the American side." The Batchawana ore bed is about seven miles to the northwest of the village of that name. The ore is principally specular iron, the less compact hematite being comparatively rare. There is also an admixture of magnetite, and both ores in narrow bands are interbedded with smaller bands of dark red jasper. The thickness of the banded bed is not less than twenty feet, and in some places cannot be less than forty. The deposit on Gros Cap presents more promising features where it overlies a bed of greenstone slate, and seems to occupy a valley running northwestward between higher rocks. The total thickness of the ore-bearing bed is about sixty feet, but the upper part is very poor, containing merely finely-disseminated ore. Various other beds were observed in the same locality cropping out upon the lake shore.[39]

Batchawana ore bed.

Gros Cap deposit.

Dr. Bell visited Gros Cap eleven years afterwards, and refers in his report to two exposures of hematite on the southern part of the cape. One of these is fifteen or twenty feet of very impure purplish red hematite, interstratified with thin, drusy, gray, silicious beds, the band dipping south 30° west at an angle of 70°. The second is near the southwest extremity of the cape and had been worked several years previously. It is about twenty feet in thickness, consisting of thin and very distinct and regular ferruginous beds. "The best layers appear to be a sufficiently rich iron ore, but it is questionable whether the earthy beds do not form two large a proportion to make it profitable to mine the whole mass in order to obtain them."[40]

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[35] Report of the Commission, pp. 123 and 143.

[36] Geological Survey of Canada, 1876-7 p. 210

[37] Geological Survey of Canada, 1857, p. 24.

[38] Mining Commission's Report, p. 143.

[39] Geological Survey of Canada, 1863-6, pp. 129-31.

ORES NORTH AND WEST OF LAKE SUPERIOR.

North of lake Superior.

An exploration survey of the country north of lake Superior between the Nipigon and Michipicoten rivers was made by Robert Bell during the years 1869-70, and in his report reference is made to the occurrence of thick beds or veins of magnetic iron ore in massive crystalline granitoid rock of red orthoclase and black hornblende at the mouth of the Little Pic river. The ore occupies a horizontal position in a cliff, and the united thickness of three of the beds appears to be about ninety feet. One sample of this ore yielded 36 per cent. of metallic iron, and another from a different part of the deposit 46 per cent. A band of impure solid hematite ore was also found on the west point of the largest of the Slate islands, and a silicious slaty magnetic ore was found to occur as a band two feet in thickness on the portage at the west end of Little Long lake.[41] William Murdoch, civil engineer of Port Arthur, informed the Mining Commission that he had sold an interest in a very large deposit near Loon lake where there is said to be a million tons of ore in sight. On Ruby lake also he stated that there is a deposit of hematite which will go 65 per cent.[42]

Ores on Loon and Ruby lakes.

The Vermilion and Mesabi iron ranges of Minnesota extend into Ontario.

The two great iron ranges of Minnesota, the Vermilion and Mesabi, have been traced northeastward into Ontario. The Vermilion enters our Province at the eastern end of Hunter's island, and numerous outcroppings have been discovered on the range across that island.[43] Prospectors also report the appearance of ore at a number of places inland, and although careful exploration has not been made it is probable that the ore deposits on the Mattawan river are on the continuation of the Vermilion belt. In the report of the Mining Commission Michael O'Keefe of Tower, Minn., is credited with saying that he had explored Hunter's island north of Emerald lake and traced a deposit of iron ore a total distance of eight miles, the width of which varied from 50 to 300 feet. James Sheridan also informed the Commission that he had explored Ontario on the north side of Knife lake, on the east of Hunter's island, and took up an iron location there. He described the ore as a hard red hematite mixed with jasper, like the Vermilion, and lying between walls of diorite and chloritic slates. The deposit is 90 feet wide, and the bed can be traced for three miles along the strike. Assays of the ore showed it to run from 47 to 56 per cent. of iron, and Mr. Sheridan thought that it would average about 50 per cent.[44]

On Hunter's island and Knife lake.

Features of the Mesabi range.

The Mesabi range has been carefully explored during the last three years by Mr. H. N. Winchell of the Minnesota Geological Survey, and a valuable report by him has recently been published upon it. This range lies at the base of the Animikie formation, and has been traced northeastward into Ontario, crossing the boundary at Gunflint lake and curving around to the head of Thunder bay, east of Port Arthur. It is an iron-bearing belt over a large portion of its length, but the ore varies in richness, and in many stretches the range is lean or altogether barren, as indeed is the case with almost every known iron belt of considerable length. West of the Duluth and Iron Range Railway the ore is found under deposits of clay and gravel, and when uncovered it may be scooped out and loaded on to cars with a steam shovel, being almost of the consistence of fine sand. It is of the hematite variety and of different colors and shades of colors, red, blue and brown. East of the Iron Range Railway the ore beds are covered by strata of black slate, or of an eruptive rock called gabbro which was poured out over them like volcanic lava. The effect of this overflow of molten rock, in the opinion of Mr. Winchell, was to convert the hematite into a magnetic ore. In the northern part of the state, and on the Ontario side, the ore on this range is almost invariably magnetic as far as known ; but possibly there are sections of it over which the gabbro did not extend. South of Gunflint lake, on the Minnesota side, mining operations have been carried on during the past year, and it is expected that ore will commence to be shipped this year to Fort William over the line of the Port Arthur, Duluth and Western Railway. The superintendent of the Barnum mine at Ishpeming, Mich., Mr. William Sedgwick, gave to the Mining Commission some information respecting ore deposits on this range on Gunflint and North lakes. On the north side of the first-named lake he stated that there is a rich magnetic ore suitable for Bessemer steel, the analysis of which gave 68 per cent. of iron, .028 per cent. of phosphorus, no sulphur, and very little silica. He satisfied himself that there was at least 25 feet in thickness of this ore, but how much more he did not wait to determine, lest some one might take advantage of his discovery and purchase the property from the Government before him He also obtained specimens from drift boulder and ledges of good quality ore at several other places on the north side of both lakes.[45]

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[40] Geological Survey of Canada, 1876-7, p. 220.

[41] Geological Survey of Canada, 1870-1, pp. 347-8.

[42] Report of the Commission, p. 144.

[43] "Hunter's island is interesting economically chiefly for the iron ores associated with jaspery beds which occur on its southeast side, and which are entirely analogous geologically to the famous iron ores of Vermilion lake at Tower, Minnesota." Geological Survey of Canada, 1888-9, p. 27A.

[44] Report of the Commission, pp. 125-6.

Ore on Gunflint and North lakes.

Grady.

Michael Grady of Kingston, an explorer, has given the following information to the Bureau respecting the iron ores in this region, on the Ontario side of the boundary :

Exploring on the Mattawan river.

"I am in the employ of the Kingston and Pembroke Mining Company as prospector. I have been prospecting on the Mattawan river a tributary of the Kaministiquia, and also on Gunflint lake near the Minnesota boundary. I was there in company with Mr. Williams, P. L. S., of Kingston. We took up and explored seven locations on the Mattawan. These locations are situated about twelve miles southwesterly from Finmark station on the C.P.R. The ore we found there was a hard hematite. We explored the location called W 222, with the diamond drill which we had taken there the previous winter. We put down four holes to a depth of about 300 feet and found ore most of the way down. We had several assays made of it which averaged 50 per cent. metallic iron, and contained no objectionable impurities such as sulphur, phosphorus or titanium.

"The hill in which the ore occurs rises to a height of 100 or 150 feet above the level of the surrounding country. The ore crops out in the direction of the strike of the rocks, which is about north 70° east. The dip is nearly vertical. The next best location is W223, adjoining the above-mentioned on the west. The ore appears to be more solid here and has a somewhat slaty structure. The hill in which it occurs is about the same elevation as that on W222. The strike and dip are also the same on both locations. The country rock on the south side of the ore outcrops is greenstone, and on the north side a chloritic schist which sometimes partakes of the nature of a conglomerate. We did not use the diamond drill on W223, but put down three pits to a depth of eight or ten feet. Samples of the ore obtained

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[45] Report of the Commission, p. 126.

Grady.

assayed over 60 per cent. metallic iron, with no objectionable impurities; good Bessemer ore. We did not find any outcrops of ore west of this location.

Extent of the ore bodies.

"As regards to the extent of these ore outcrops, I should say that on location W222 the deposit is about one-fourth of a mile in length and about 200 feet in the widest part, narrowing to about 50 or 60 feet at its eastern and western extremities. On location W223 the outcrop is nearly half a mile in length. In one place it is 400 feet wide. It narrows and becomes split up towards the southwest end.

Horizontal beds of ore at Gunflint lake.

"At Gunflint lake the ore deposits are not so well defined. They are in nearly horizontal beds. We found some very good ore there. Assays gave about 60 per cent. iron with no objectionable impurities. We did no work there, except sinking a few test pits through the soil down to the ore-bed. The ore is different from the Mattawan, being magnetic. I should say that the Gunflint and Mattawan ranges are about 40 miles apart, the latter being northwest of the former.

"We have not done anything along the Kingston & Pembroke road this year. The mines are all idle. I have not done any prospecting there either. At the present prices of iron ore we can't work these mines and ship the ore to the States in the face of the McKinley tariff. If the duty was off we could work them at a fair profit. There are no iron mines down here being worked this year that I know of."

Williams.

David Williams of Kingston, a Provincial Land Surveyor, has been engaged in exploring for minerals and surveying mining locations in the same region for three years, and the following statement has been furnished to the Bureau by him:

Locations near the international boundary, at Gunflint lake.

"I am a Provincial Land Surveyor and reside in Kingston. I have been engaged during the last three years in mining surveys and explorations in the regions west of Port Arthur in the Thunder Bay district. I have made surveys and explorations at Gunflint lake along the international boundary, and had some test pits sunk on locations R311 and R317, where we found some very promising beds of ore. Assays gave about 60 per cent. metallic iron, with no sulphur, phosphorus or titanium. The ore lies in nearly horizontal beds, in what is sometimes called blanket ore. One deposit extends from location R205 westerly across R315 and partly across R317, It is from 50 to 150 feet wide. We did not do any blasting, so that I cannot say much about the depth or thickness of the bed, but its superficial area is so great that it will in any case yield a large amount of ore.

"Another deposit lies along the northern border of location R311. It crops out of the side of a high hill, where it occurs in layers of varying thickness, alternating with thin layers of shale and rusty quartzites. There is every indication of a large body of ore. It can be traced along the side of the hill for nearly half a mile. I have since traced this ore formation northeasterly to near the southern boundary of the township of Strange, and have discovered a number of localities which give strong indications of the presence of valuable ore beds. There is no doubt but that this range is a northeastern extension of the celebrated Mesabi range in northeastern Minnesota.

Locations on the Mattawan iron range.

"In the fall of 1890 I examined what is now called the Mattawan iron range. Mr. James Hammond of Fort William had prospected the range during the previous summer and had made some important discoveries. I reported very favorably and Mr. Hammond was joined by Messers. Folger Bros. of Kingston, and together they took up 17 locations along the range. Since then we have done some development work in different places on the property. The work on W222 and W223 has been described in Mr. Grady's evidence. During the last year Mr. Hammond has sunk a shaft to the depth of about 60 feet on location W211. This locality presents some very interesting features. One formation is about 200 feet wide. The surface rock

Williams.

consists largely of banded jasper and iron all broken up into small angular blocks, which a short distance below the surface are cemented together with iron, forming a breccia with the iron filling the spaces between the angular blocks and forming part of the blocks themselves. The jasper in the ore steadily diminishes with the depth, and we have good reason to believe that it will work out altogether a little deeper down. The ore is a fine-grained specular, very pure in spots. Large pieces could be obtained that would carry 65 to 68 per cent. of iron.

Exploratory work at Middle Falls, on the Mattawan.

"Two or three excavations were also made on location W 219, near what is called the Middle Falls on the Mattawan river. The ore formation is here about 200 feet high. The workable ore bed is about 60 feet wide and can be traced a long distance on the line of strike. It is thrown up into a hill about 200 feet wide. The excavations were in the form of cross-cuts into the hill, and they exposed a large fine body of ore. I think the assays gave about 54 per cent. good Bessemer ore. The Mattawan range can be traced eastward beyond the Kaministiquia station of the C. P. R.; but in this direction the ore becomes very lean, and large belts of jasper seem in some places to occupy the ore horizon. The ore belt seems to follow the axis of a synclinal, and I think that the folding of the ore bed upon itself will account for its great width in some places. On location W 223 it is 400 feet wide. It is by far the largest body of ore I have ever seen, and I believe it is one of the largest on record."

Conmee.

James Conmee, M.P.P., has furnished the Bureau the following information on the iron ore occurrences in the same localities:

Object of the Port Arthur, Duluth and Western Railway.

"I have been engaged in building the Port Arthur, Duluth and Western Railway. The line in Ontario is now completed, the distance being 87 miles to the international boundary at the southwest end of Gunflint lake. Our object was to reach the iron ore on the American side as well as the Canadian. For this purpose we have constructed six miles of road on the American side. We have a contract with the Gunflint Iron Company by which they undertake to ship 1,000,000 tons of iron ore at the rate of 100,000 tons a year. I have seen the deposit of iron ore at Gunflint lake, and it appears to be an extensive one. The outcrop, which occurs along the base of a high ridge of rock, varies in width from 10 feet at some points to 100 feet at others. I stepped along the outcrop, which was stripped in places, and found the length to be about 3,000 feet. I think there is a large body of ore there, and there is more further on; a mile beyond this place a diamond drill was set at work and it struck ore running in the same direction. I understand that pretty extensive tests have been made with the diamond drill, and a large body of magnetic ore is said to have been found I am told the ore assays from 63 to 67½ per cent. of metallic iron. It is almost entirely free from phosphorus, and contains very little titanium; it is claimed to be a first-class Bessemer ore. The ore will be sent over our line in bond, and then shipped on to Cleveland or some other place. I have reason to believe that the same range of ore crosses the boundary line into Ontario. It comes across right along our line of railway, at the Narrows between Magnetic and Gunflint lakes; I have seen several outcrops there myself. The greater part of the land on which these deposits occur is owned by Caldwell & Co. of Lanark, and Folger Bros. of Kingston. They had Mr. Williams there, and Mr. Michael Grady, both mining experts, who reported on the property and claimed to have found a very large body of ore. They stripped the ore in places, sunk several test pits, and had a number of men working there during the whole of the summer of 1891. They have not mined the ore at all; but they say that it is the same ore in appearance and quality as the American ore. The range has been traced into Ontario in a northeasterly direction as far as the vicinity of Whitefish lake, a distance of 35 miles far-

Ore bodies in the vicinity of Gunflint lake.

Tracing the range into Ontario.

ther ; there are outcrops of ore all along, in several places. It has not been traced beyond Whitefish lake. The Gunflint range, both on the Ontario and American sides, is a continuation of the Mesabi range in Minnesota. This at least is the general opinion of geologists. Mr. Winchell, assistant state geologist of Minnesota, was over there a few weeks ago, and he told me it was a continuation of the Mesabi range. The only difference is that so far as it has been developed the ore at this end is a hard ore, while at the other it is a soft ore in places.

Conmee.

"There is another range of iron ore about four miles north of the one I have been speaking about, on the Ontario side, just lately discovered. I do not know much about its extent, but the ore is of very fine quality ; it assayed 65½ per cent. of iron and carried also a good percentage of manganese. This range is near Sand lake, four miles from our railway. The deposit has been found to be a large one. A pit has been sunk about 15 feet, and as far as the pit has shown up the vein it seems to be very much decomposed. They had not got down to what they considered the solid ore. The manganese appears to be dispersed among the ore, but it also occurs in pockets ; they have taken out small quantities of manganese almost pure.

A parallel range near Sand lake, showing rich ore.

"I also know of the occurrence of iron ore on the Mattawan river ; I have been there. The principal owners are the Folger Brothers of Kingston. I own a location there myself, and Mr. Pumpelly and his friends own a very large block of land there. They have surveyed and explored it, but I do not think they are interested with Folger Bros. The latter have tested their locations with a diamond drill ; I am not aware that others have done so. I believe the ore there to be very extensive ; the vein is three hundred feet wide in places, and at no place that I saw was it less than 75 feet wide. The ore crops out at the surface in very many places, and is quite easily traced for 20 miles, running in a southwesterly and northeasterly direction. It is mostly hematite ; all that I saw was hematite. It is apparently not quite so rich an ore as the Gunflint or Atik-okan ores on the surface, from which assays show 45 to 55 per cent. of iron ; but where the prospectors bored with a diamond drill they have got very much better results ; they have got as high as 62 per cent. according to my information.

The Mattawan range.

"There are outcroppings of iron ore farther north, but not of the same permanent character. The range crosses the Kaministiquia river about 20 miles west of Port Arthur, above the falls. This is not the range which extends into the townships of Ware and Gorham. The latter is a hematite ore, what I would call an iron slate. It occurs in a sort of slaty formation, and I should take it to go about 30 or 35 per cent of iron."

Other ore ranges farther north.

The following paragraph on shows of iron ore on the Kaministiquia river is taken from Dr. Bell's report to the Director of the Geological Survey :

Ore shows on the Kaministiquia river banded with jasper.

"In the hills on the left side of the Kaministiquia river a finely-banded rock made up of jasper and magnetic iron occurs at the distance of one mile southeast of the junction of the Mattawan. The alternating beds are usually not more than from one-half inch to two inches thick, and present a very striking contrast ; the jasper being brown or bright red, while the magnetic iron is black, finely granular and glistening. The beds are somewhat contorted, but their general strike appears to be about east and west. On the west side of the Kaministiquia river, at about a mile and a half below the Mattawan, the same ribboned jasper and iron ore rock occurs, associated with black arenaceous layers, semi-translucent banded chert, approaching chalcedony, and dark fine-grained hard ribboned argillite or felsite, having a conchoidal fracture. These strata are considerably contorted and dip at high angles, but their general course appears to be northwestward."[46]

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[46] Geological Survey of Canada, 1866-9, p. 330.

Red hematite on Arrow lake, and slaty iron on Nipigon lake.

Dr. Bell also mentions the occurrence of iron ore at many other points west and north of lake Superior, specimens of which were shown to him, among them being pure red hematite from Arrow lake and a slaty iron ore from the east side of lake Nipigon. The latter was found to contain 51.51 per cent. of peroxide of iron (= 36.06 metallic iron), traces of manganese, .076 per cent. phosphoric acid and 8 of alumina.

THE ATIK-OKAN IRON RANGE.

A belt 15 miles in length.

Going farther west another extensive range of magnetic ore is found on Sabawe lake and Atik-okan river, which has been traced a distance of 15 miles westerly on the course of the river to its junction with the Seine. Large deposits have also been discovered down in the valley of the Seine, but some analyses show these ores to contain titanium. Referring to the deposit on the Atik-okan or Antler river in the Mining Commission's report, Dr. Bell describes it as a large body of magnetite of fine quality. There are three beds in the widest part, each about fifty feet in width, separated from each other by narrow bands of rock running with the general course of the belt to which they belong. "The deposit," Dr. Bell wrote, "shows workable quantities of ore at intervals for about three miles, and is traceable for about five miles." But more recent explorations show that outcroppings occur over a distance of fifteen miles. Dr. Bell also refers to another rich deposit near the mouth of the Seine river, and one of lower grade ore at a straggling lake southeast of Wabigoon lake.[47]

Conmee.

Mr. Conmee, M.P.P., who has been over the Atik-okan range, has supplied the following information respecting the shows of iron ore upon it:

"I have been on the Atik-okan range and have examined the iron ore there. This is the greatest deposit of iron ore I ever saw. There is a vein varying from 40 to 150 feet in width, and rising up to a height of 100 to 150 feet in places, and extending, so far as my observation goes, for about 25 miles. I have followed it for that distance myself, and it appears to be a continuous outcrop all the way, of pretty uniform width, but varying in height, dipping in places and rising again. It has been tested with a diamond drill on several locations by Thomas Marks & Co.; they have tested on locations of their own, and on those belonging to some Americans. The ore is magnetic On the surface it is a little decomposed, but it is all ore: there is very little mixture with it. It is said to carry a considerable percentage of sulphur, which is its only drawback, so far as I know. It runs up to 65 and 67 per cent. of metallic iron, and is of this uniform richness. It is a very rich ore.

Tracing the length of the range.

"This range is about 80 miles from any present railway; the northeast end of the range would be about 50 miles from the Canadian Pacific, at Fire steel river, or a little west of that point. The property could not be worked until a line of railway was constructed. The line of the Ontario and Rainy River Railway runs right across the southwest end of the range. This line has been located.

Want of railway communication.

"There are no facilities for getting out the ore from the Mattawan range. There are portions of the vein which occur within about 8 miles of the C.P.R., near the Kaministiquia river. The deposit gets much richer farther west, and couldbe tapped either from the Port Arthur, Duluth and Western or the C.P.R. by a line of railway some 30 miles in length. The other deposits of ore are within convenient distance of the former railway."

McKellar.

The following description of the Atik-okan iron range was written by Peter McKellar and published by the Bureau of Industries, 1886, p. 409:

"This great magnetic iron deposit, on locations 10 E, 11 E and 12 E on

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[47] Report of the Commission, p. 22.

McKellar.

Locations 10 E 11 E and 12 E described.

Extent of the ore lode on Iron mountain.

the Atik-okan river, lies about thirty miles southwest of Bridge River station, Canadian Pacific Railway, which station is about ninety miles west of Fort William. The ore lode, which is divided into two or three branches in places, as at Iron mountain, has been traced by the outcrops for a distance of nearly four miles along the strike of the formation, with which it appears to conform in dip and strike. The formation consists of the Huronian green chloritic and dioritic schists, with a dip nearly vertical, or about 80° to 85° to the horizon northward. Herein I will describe Iron mountain only, the middle portion of the above run of ore, which is largely exposed and of which the examination was well and carefully made. The ore lode aggregates a thickness of 100 to 125 feet, divided into two and in places three veins by a belt or belts of the green schist 20 to 60 feet in thickness. This with the associated rocks forms a mountain range nearly a mile in length and 300 to 400 feet in width, and that rises to elevations of 60 to 125 feet above the surrounding plain ; it therefore presents unusually favorable natural advantages for turning out a large quantity of ore in a short time. The ore is remarkably uniform in grade or percentage, and is described as follows by Professor Chapman of University College, Toronto, the leading authority on iron ores in Canada.

Analysis.

"'The sample consists of fine-grained, comparatively soft black magnetic ore. As shown by analysis the ore is exceedingly rich in metal, holding 70 per cent. metallic iron, with very little silicious rock matter, very small amounts of sulphur and phosphorus, and no trace of titanium. Its specific gravity equals 4.93 ; hence the weight per cubic foot is equivalent to 307¼ pounds. So far as regards composition and physicial characters, a better ore could not be obtained.'

Ferrous oxide	29.98	=metallic iron......23.32	=70.06.
Ferric oxide	66.77	= " 46.74	
Titanic acid	None.		
Sulphur	0.06	..(strictly 0.062).	
Phosphorus	0.02	..(strictly 0.025).	
Alumina	0.67		
Silica	2.43		
	99.93		

" After the above sample test the deposit was systematically tested by American iron experts, who pronounced it first-class in every respect. The lode was closely sampled at several points and different samplings analysed, none of which showed titanium or sulphur. The percentage of metal was high, being 63 to 70, and the phosphorus low, or 0.011 to 0.035.

" The regularity of the stratification of the ore and schists along the surface shows that the ore deposit is not superficial or liable to give out quickly downward any more than it does along the surface horizontally. The lode may change in size a little either way in sinking 400 to 500 feet ; but here it will be more likely to be in the direction of an increase rather than that of a decrease on account of the dip of the outside walls along the middle portion of Iron mountain.

Estimate of ore in Iron mountain.

" After a thorough surface examination of the Iron mountain lode, I estimate the quantity of good ore to exceed 2,000,000 tons for the 100 feet of depth, or 10,000,000 for 500 feet. I doubt if there is any other known iron deposit in either Canada or the American great iron districts of lake Superior that gives a more valuable show in regard to quality, quantity and the natural advantages presented for mining.

" The difficulty in the way of its present development is the distance to a railway or to navigable water. To make the ore available would necessitate the building of a railway branch thirty miles in length to connect with the Canadian Pacific, and negotiations are in progress that promise to result is the commencement of the work at no distant date. So much wealth as is known to exist here and the great trade its opening would create in the district are sure to cause the building of this branch before long.

McKellar.

"Besides the iron trade, the building of the proposed branch would open up other valuable industries in the locality. The rock formation consists largely of metamorphic schists associated with granite, a formation highly favorable for the bearing of metals. Even now, although the locality is but slightly known to the mineral explorer, two very promising gold veins (Partridge Lake and Osinawe lake veins) have been discovered within a radius of six miles of Iron mountain. There are some good tracts of timber lands in the locality ; also farming lands, such as that in the grand valley of Seine river along which the proposed railway branch would run for the greater portion of its length. The Huronian and Animikie formations, the iron bearing rocks of the American iron districts on lake Superior, are largely developed in Canadian territory north of lake Superior and the American boundary."

Wiley.

The following statement has been furnished by Harold A. Wiley of Port Arthur, whose firm is interested in the Atik-okan range.

Locations west of lake Sabawe.

"I reside at Port Arthur and am a member of the firm of Thomas Mark & Co., merchants, forwarders and shipowners. For the last five years I have been dealing to some extent in mining lands, and I have also prospected in various parts of the district. Five years ago I became aware of the existence of iron ore on the Atik-okan river west of lake Sabawe, through the report of Indians. Two years previous to this Messrs. McKellar and Graham had discovered and taken up locations east of the lake which were reported to contain very large deposits of magnetic ore. In the summer of 1887 we sent out a party of explorers who continued in the field for several months and reported to us a discovery of ore west of the lake which showed outcroppings five miles in length. This is a continuation of the McKellar range, and the ore is of the same character. It is a series of low hills sixty to eighty feet in height, with intervals of low ground, the ore occurring in lens-shaped masses varying in width from ten to forty feet. The lenses are of various lengths, from one to ten chains. We carried on explorations with a diamond drill for six months during the season of 1891, having taken the drill in from Savanne station on the C.P.R. during the previous winter. Sixteen holes in all were bored, eight on our own properties (R400, 401 and 402) and eight on another location adjoining ours on the west (X212). On R400 the total extent of drilling was 340 feet ; on R401, 792 feet ; and on X212, 1,010 feet. In one of the vertical borings ore was found to a depth of 265 feet (this being the length of the drill rods) which averaged 64 per cent. of iron and showed only a trace of phosphorus. Some of the cores analyzed 68 per cent. iron. I am fully satisfied with the quantity and quality of the ore on the Atik-okan range. An eminent American geologist who examined it carefully assured me that upon two locations alone the quantity in sight was not less than 1,500,000 tons, and the range is at least thirteen miles in length."

Diamond drill explorations.

Two years ago last October W. W. Russell, P.L.S., of Port Arthur furnished at my request the information contained in the following paper on the Atik-okan range :

Russell.

"During the past summer the extensive and rich deposits of magnetite on the Atik okan river, about one hundred miles west of Port Arthur, have attracted much notice from iron mining men, especially Americans, and have been visited by many prominent parties. The extent and high grade of the outcroppings have excited surprise invariably, though some expressed disapointment at finding no development work done.

First discovery of iron ore on the Atik-okan river.

"Some five years ago the first discovery of magnetite in this range was made, and a tract taken up by Messrs. Graham & McKellar. The property was shortly afterwards examined by Mr. D. H. Bacon (now superintendent of the Minnesota Iron Co.), and on his report bonded for a long term to a Cleveland party represented by Major Pickands. No active operations have

Russell.

been begun. The discovery of the iron did not attract general notice in any way until the finding last fall of another equally extensive and rich deposit, several miles further west on the same range. The result of this was the starting of numerous exploring parties this summer, and the discovery of still other outcrops of the same ore further westward, until now these rich deposits have been traced by outcrops for a length of sixteen miles along the belt.

"Nothing more than a superficial examination of the deposits has been made in the way of a few surface cross-cuts, and an occasional shot to secure unweathered samples ; but in many places the ore outcrops boldly, showing a varying width of from 10 to 50 feet.

Geological occurrence of the deposits.

"Before describing these outcrops or surface showings more minutely, I may refer to the geological occurrence of the deposits. They occur as beds in Huronian hornblendic and chloritic schists, which are nearly vertical, having a dip of 86 degrees north, and a strike of north 75 degrees east. The surface showings indicate that there are several of these beds, the intervening rock having a width of from five to thirty feet. Whether these beds will unite at a depth or maintain their separate identity, is a problem for development work to decide. The Huronian belt has an average width of eight miles, and rests conformably in the folds of the Laurentian rocks, so we may presume its depth (and that of the interbedded magnetite) to be very considerable, practically unlimited.

The McKellar Graham location, east of Sabawe lake.

"The McKellar-Graham property is the most easterly on the range, and its most conspicuous outcrops occur on the summit and both faces of a bluffy ridge running nearly east and west 100 feet above the level of the Atik-okan river. Mr D. H. Bacon sampled the surface showing here, taking samples at three-inch intervals ; and for an aggregate width of 80 feet these samples gave 63½ per cent. metallic iron, without more than a trace of titanic acid or phosphorus, and little more than a trace of sulphur. The outcrops here showed three beds of ore.

The range west of Sabawe lake.

"Immediately west of the McKellar-Graham property is Sabawe lake, a sheet of water three miles in length. For some distance west of the lake, in the course of the iron belt, a considerable depth of soil covers everything ; this extends to location R400, on which and R401 other outcrops occur very similar to those on the McKellar-Graham property. A similar ridge traverses these locations, and in many places, especially on the southern exposure, which is very steep, large outcrops occur. Having closely examined these and several locations adjoining them on the west, I can speak more definitely of them than of others where my inspection was more cursory ; and it may be as well to state here that the ore throughout this range varies but slightly in character or grade ; it is virtually identical throughout, though in some places where greatly exposed to atmospheric action it is, of course, leaner. On location R400, where a natural exposure of ore some twenty feet in width occurs, a large number of samples taken at random gave from 66 to 68½ per cent. metallic iron. On the location west of this, R401, a surface cross-cut was made this summer which showed 46 feet in width of ore ; the full width was not ascertained, as the cut was abandoned on account of the depth of overlying soil and large boulders. Some of the ore from this cut, when protected by deep soil, gave as high as 71 per cent metallic iron.

Tracing the range westward

"A little more than half a mile west of this the ore again outcrops on the south face of a ridge about fifty feet in height, the intervening ground being low ; samples from here gave 65 per cent. Half a mile further west a short trench dug in the low ground showed rich ore at a depth of only three feet, no attempt was made to uncover the width of the deposit, the sole object being to locate it. A mile beyond this numerous showings are found along the top and south face of a ridge about 100 feet high ; the surface showings here are very extensive, and the ore of the same high grade, 66 to 68 per cent. For nearly three miles beyond this the ground in the line of the deposits is very low, and no attempt to locate the ore by test pits etc., has been made. As the ground rises, the ore again outcrops and shows at the crossing of the Atik-okan river, which is very rapid at this point. Beyond this I have made no personal examination, but have been informed by several who have been over the ground that about a mile and a half west there is another extensive outcrop on a high ridge similar to those already referred to. The country is very low and swampy for some miles, and no further discoveries have been made—or perhaps I should say made public.

"Although no development whatever has been done, the surface showings alone indicate the presence of an enormous amount of iron, which is uniformly free from injurious elements, and of an astonishingly high grade, and I am of opinion that much of the leaner silicious ore which is now ignored in sampling will at a depth become a good marketable ore. Many of the natural outcrops are on the south slopes of the ridges, and are much weathered and oxidised, resulting, of course, in the impoverishment of the ore.

Railway communication.

"To bring the Atik-okan ores to a market, a railway from 30 to 50 miles in length will have to be built from near Carlstadt station on the Canadian Pacific Railway to and along the Atik-okan river. An examination of the route was made by the Canadian Pacific Railway company last fall, and their engineer reported it a very easy one, estimating the cost of grading at not over $2,000 per mile for four-fifths of the distance, the balance being medium work only, to cost say $10,000 per mile. The company are not disposed to build the road unless a reasonable amount of freight is guaranteed, but are willing to equip and operate the road when built if desired, and to facilitate the successful operation of the mines by cheap freight rates, etc. There is no local traffic for the railway throughout this section, and it is plainly to the interest of the company to promote to the utmost any undertaking that might lead to making this part of the line a remunerative one through local traffic. That they are fully alive to this is very evident in all intercourse on the subject with the chief officials of the company.

Market for the ores.

"With regard to the market for these ores, and the cost of delivering them thereat: Mining will cost from 75 cents to $1 per ton, say $1 as an outside estimate. Railroad freight to Port Arthur or Fort William, $1 per ton. Lake freight to either of the principal ore ports on lake Erie, Cleveland or Ashtabula, may be taken as the same as that from Ashland or Two Harbors, the shipping ports of the Gogebic and Vermilion districts. The rate last year and during the present season has been about $1.25 per gross ton, and there is no reason to think this will be exceeded in the future, considering the continual increase in numbers and tonnage of vessels built on the lakes. Shipping charges, insurance, etc., may be taken at 30 cents per ton; duty going into the United States, 75 cents per ton. This will give the total cost, delivered at a lake Erie port, of $4.30 per ton. The present value of a high grade Bessemer ore, such as this under consideration, delivered on the docks at Cleveland or Ashtabula, is $6 per ton, which would leave a net profit of $1.70 per ton.

Shipments.

"The total lake shipments of iron ore amounted in 1888 to 4,700,000 tons, in 1889 to 7,300,000 tons, and up to and including 1st October of the current year, 6,480,000 tons. If the shipments for the balance of the season only equal those of the same part of last year, the total for 1890 will be about 8,500,000 tons.

"The Dominion Government gives a bonus of $2 for every ton of pig iron manufactured in Canada, and a portion of the Atik-okan ores might be profitably treated at Port Arthur or Fort William, where other ores for mixing, flux and fuel can be brought at low rates. Coal is carried here from lake Erie ports at from 40 to 50 cents per ton, and coke from 80 cents to $1.

Russell.

There is no duty on anthracite coal, and coke also is admitted free for smelting purposes.

"I append hereto a number of analyses of the Atik-okan ore from different parts of the range, and also a plan showing the locality, etc.

Analyses of samples of ore taken from the McKellar-Graham locations.

	1	2	3	4
Silica	6.60	7.30	5.89	2.43
Alumina	1.09	1.80	.98	0.67
Ferrous oxide	none	none	none	23.32
Ferric oxide	87.66	86.90	88:36	46.74
Manganesic	trace	trace	trace	
Calcic	1.28	0.90	1.40	
Magnesia	0.75	0.60	0.75	
Phosphoric acid	.0079	0.069	0.025	
Titanic	none	none	none	none
Total	94.46	97.57	97.41	none
Metallic iron	63.47	62.84	63.97	70.06

The first three are averages from the three beds sampled by D. H. Bacon, of the Vermilion mines in Minnesota, and the last is a single specimen by Prof. Chapman of Toronto.

Samples taken by W. W. Russell from locations B400 and B401 :

	1	2	3
Metallic iron	68.50	65.90	65.702
Silica	2.90	5.80	4.20
Phosphorus.	0.015	0.001	0.003
Sulphur	0.052	0.16	not specified
Titanic acid	none	none	none

Assays by Sharon Iron Works, Pa., of samples furnished by Capt. M. N. Garland from property marked "Garland locations :"

Metallic iron	68.75
Silica	1.41
Phosphorus	0.006
Sulphur	0.185

Assays of Atik-okan ore by Dr. Hoffman, assayer of the Geological Survey of Canada :

1. Magnetite from R402 :

Metallic iron	68.579
Titanium	none

2. Magnetite, R400 :

Metallic iron	68.027
Titanium	none

3. Magnetite from R403 :

Metallic iron	64.551
Titanium	none

4. Magnetite from line between mining locations 10E and 11E, collected by Smith :

Metallic iron	65.710
Titanium	none

Smith.

Henry Lloyd Smith of Newport, Rhode Island, who with Raphael Pumpelly has taken up several locations in this part of the Province, has given to the Bureau the following description :

Exploring for iron ore in Ontario, on the Atik-okan range.

"I am a mining engineer, living in Newport, Rhode Island. I have been on the Geological Survey of the United States for five years, and have spent two seasons, or practically two years, exploring for iron ore in western Algoma, chiefly northwest of Port Arthur. My explorations have been wholly for iron ore. I spent several weeks on the Atik-okan river, where iron ore occurs in irregular lenses in greenstone, both walls, so far as we know, being greenstone. The ore occurs in a single range; that is, the ore bodies are found within a distance across the formation of 300 feet or less. The range is found both north and south of the river, which flows parallel to it, and crosses it several times in the course of 12 or 15 miles. The exposures of ore in some instances rise above the level of the country, and are some 80 to 100 feet above the river in places. On the locations belonging to Mr. Wiley and Mr. Marks of Port Arthur, on the north bank of the river, the ore is some 70 or 80 feet above the water. The ore of course is not continuous for the entire length of the range. On this property I do not think there is a single lens of ore that can be traced for more than 200 to 250 feet. There are considerable intervals of barren rock, more or less ferruginous. The limit between the ore and the rock is not so much a geological as a commercial one; that is, the ore gradually merges into the greenstone. In the middle of the lens you have a pretty pure magnetite, then, as the edges of the lens are approached, there is a greater or less mixture of rock, then gradually more rock comes in and less ore, until finally it passes altogether into rock. The physical characteristics of the ore are those belonging to magnetite. We have had extensive analyses made of it, but I do not bear in mind the figures; so far as I remember, the highest result we got was about 68 per cent. of metallic iron, which was not from a picked sample at all, but taken at intervals from a body of the ore 18 feet in thickness, and represented the same very fairly. It was a beautiful clean ore. The general character of the ore throughout the range is that of a fairly clean ore. I am interested in the property there along with other gentlemen. We have a location about a mile in length, containing about 160 acres. So far as we can see there is a large body of ore there. but it is impossible to speak definitely as to its extent.

On Steep Rock lake.

"Besides the Atik-okan river I have been on the Steep Rock lake, which is several miles west of the Marks and Wiley locations. The iron formation there overlies limestone. There is no body of clean ore exposed, but I do not think there is any question about iron ore being there. There are fragments of iron ore in the glacial drift along certain parts of the shore of the lake. The bodies of the ore there are probably under the waters of the lake, which are very deep, and I doubt if they have any commercial value.

On the Mattawan river.

"I have also explored along the Mattawan river, where we find very hard red hematite ore banded with jasper. It has not yet been found in any commercial bodies; iron formation alone has been found there, consisting of jasper banded with hard hematite, in which one would naturally look for bodies of ore. The formation is one very similar to the one in northeastern Minnesota. There is a large amount of this ferruginous material, but as yet no ore bodies have been found. We did no exploration with the diamond drill there. I understand that some gentlemen from Kingston have done some exploration with the drill there, but I do not know anything about the results they got. I have not been over this iron-bearing formation along the Mattawan for more than four or five miles. I have found it to be practically continuous for this distance, and I have no doubt that it extends considerably further. It is very hard to say whether the range is a wide one or not. It is probable that the iron formation is folded into several parallel troughs.

On Gunflint lake.

"I have not explored along Gunflint lake; I have simply taken a trip to that district. I did not see any ore bodies there. There is a very good-looking jasper in that section, and I think a great deal more of it since the discovery of the Mesabi range than I did when I went over it. It belongs in nearly the same geological horizon as the Mesabi ores, being near the base of the Animikie series.

Smith.

The Mesabi range.

"I have been on the Mesabi range; the iron ore occurs not far above the base of the Animikie. The section shows that there is a time-break between the Animikie and the rocks beneath, which in some places are granite and in others green schists, that may be lower Huronian. Upon these the Animikie beds lie nearly flat, with a slight dip to the south. The lowest part of the Animikie is a quartzite, the thickness of which I do not know. The upper part of this quartzite becomes ferruginous and passes into ferruginous chert, which is the member containing the ore. Here and there are local concentrations of clean ore, some of which are of enormous dimensions. The great point in favor of the explorer on the Mesabi range is that the ore bodies lie flat, or at a less inclination than in any other portion of the iron districts of lake Superior. In the other iron districts these lenses are more nearly vertical, and you get simply the thickness exposed on the surface. On the Mesabi range they lie on their broad face, and you have the largest dimensions of the lens parallel to the surface. The chances of hitting any ore body that may exist on any property in exploration are thus enormously increased. In some parts of the Mesabi range the ore is not solid, but granular, of the consistence of sand; in other parts it is quite hard.

Its extension into Ontario.

"I understand that the range is being worked near Gunflint lake, on the American side, but I have not seen it. There is no doubt whatever that rocks similar to those constituting the Mesabi range extend northeastward into Ontario; they come as far eastward as Loon lake, where they seem to be cut off by the Keweenawan series.

"I have not seen any large bodies of ore in the townships of Ware and Gorham. There are possibilities that ore may be found in these townships in quantities, but I do not regard the chances as very good.

ORES NORTH OF THE HEIGHT OF LAND.

Spathic ore on the Mattagami river.

In the report of the Geological Survey for 1875-6, Dr. Bell gives an account of a large deposit of iron ore in the Devonian formation on the Mattagami river, in the vicinity of the Grand Rapids, latitude 50.30° north and longitude 82° west. "Its position is on the northwest side of the river, at the foot of the rapids. It runs along the foot of the cliff for a distance of upwards of three hundred yards, almost continuously, with an exposed breadth of twenty to twenty-five yards. The highest points rise about fifteen feet above the level of the river. The surface is mottled, reddish-yellow and brown, and has a rough, spongy or lumpy appearance, like that of a great mass of bog ore. At the surface, and sometimes to a depth of several inches, it is a compact brown hematite, occasionally in botryoidal crusts, with a radiating columnar structure; but deeper down it is a dark-gray compact, very finely crystalline spathic ore, apparently of a pure quality. The brown hematite evidently results from the conversion of the carbonate. The former yields, according to the analysis of Mr. Hoffman, 52.42 per cent. of metallic iron, while the latter shows a very small amount of insoluble matter; indeed there is, chemically, little room for impurities, since it gives rise to so rich a brown hematite. The geological relations of this singular deposit are puzzling; it may be of newer date than the limestone gorge in which it occurs. The adjacent overlooking wall of soft earthy limestone is worn into vertical caverns, with fluted and rounded walls, like the sides of great pot-holes. They are sometimes partially lined with a thin coating of a highly ferruginous carbonate. The iron ore was nowhere seen quite in contact with the rock."[48]

Borron's explorations on the Hudson Bay slope.

Mr. E. B. Borron has been employed for several years by the Ontario Government exploring the Hudson Bay slope, and it is his opinion that iron ores are to be found there in inexhaustible quantity. In his evidence before the Mining Commission he stated that, as far as yet discovered, these

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[48] Geological Survey of Canada, 1875-6, p. 321.

Varieties of iron ores reported by him.

ores are chiefly carbonate of iron associated with limestone; rich brown hematite ore, resulting, as would appear, from the decomposition of the carbonate; bog-iron ores, magnetic ore and specular ore. The carbonate, brown hematite and bog ores, Mr. Borron says, doubtless exist in very large quantities. Magnetic ore has been found in places near the height of land, and probably in considerable quantity, but specular ore has been found only in loose or float pieces.[49]

Conclusion.

This sketch of the iron ores of the Province is of necessity fragmentary and incomplete. No individual man has been able to explore the whole field. The officers of the Geological Survey have been working upon it for half a century, yet there are thousands of square miles in the mineral-bearing regions of the Province which remain virgin ground for them. Prospectors have traversed many districts in a hurried way, but there are large areas which their wandering feet have not trodden. Nothing has been attempted here but to bring together, in condensed form convenient for reference, the information which scientific explorers and mining prospectors have gathered, and which has been recorded in reports, documents and papers of different kinds during the last half century. Doubtless many other bodies of ore will be discovered, especially when mining operations begin to be carried on; and some time in the not far off future the Bureau may be able to present a fuller, more accurate and better rounded report on those latent resources of our Province than is possible at present. But the information now given may be the means of aiding and stimulating further search, and may possibly also be the means of directing the attention of capitalists and iron masters to a realm of opportunity second to no other remaining open to enterprise upon the American continent.

ONTARIO'S IRON ORES AT THE WORLD'S FAIR.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

As an Appendix to this paper I give the Catalogue of Iron Ore exhibits made by the Province of Ontario at the World's Columbian Exposition, prepared by Mr. David Boyle, the officer in charge. It will be noticed that numerous localities are represented in this collection to which no reference has been made in the foregoing pages. The number of samples shown is 120.

1. Magnetite: Wilbur mine, lot 3, concession 13, township of Lavant, county of Lanark. Extent of deposit, 1,200 feet by 15 feet. Average lots analyze 60 per cent. iron, 6.31 per cent. silica, and .009 per cent. phosphorus, but the sample exhibited will yield about 68 per cent. iron. William and Thomas B. Caldwell, Lanark.

14. Magnetite: Lot 22, concession 9, township of Wollaston, county of Hastings. Length of deposit, one-quarter of mile; breadth, 25 feet. Thomas Nugent, Nugent P.O.

15. Magnetite: Lot 17, concession 8, township of Wollaston, county of Hastings. William Jenkins, Madoc.

16. Magnetite: Lot 15, concession 2, township of Wollaston, county of Hastings. Area of deposit, 500 feet by 180 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

17. Magnetite: Lot 17, concession 8, township of Wollaston, county of Hastings. Area of deposit, 1,500 feet by 30 to 120 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

18. Magnetite: Lot 18, concession 8, township of Wollaston, county of Hastings. Samples from a depth of 20 feet. Area of deposit, 1,500 feet by 40 to 60 feet. Clute & Brown, Belleville; Jenkins & Chambers, Madoc.

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[49] Report of the Commission, p. 69.

19. Magnetite : Lot 15, concession 1, township of Wollaston, county of Hastings. Length of bed, 1,200 feet ; breadth, from 25 feet to 100 feet. Jenkins & Chambers, Madoc.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

20. Magnetite : Township of Wollaston, county of Hastings. Jenkins & Chambers, Madoc.

21. Magnetite : Lot 16, concession 2, township of Wollaston, county of Hastings. Area of deposit, 1,400 feet by 25 to 50 feet. Clute & Brown, Belleville ; Jenkins & Chambers, Madoc.

22. Magnetite : Township of Wollaston, county of Hastings. Jenkins & Chambers, Madoc.

92. Magnetite : Calabogie mine, lot 16, concession 8, township of Bagot, county of Renfrew. An analysis of one lot gave 66.34 per cent. iron, 1.04 silica, .140 phosphorus, titanium a trace, and no sulphur. Calabogie Mining Company (Limited), Perth. Ontario Government collection.

93. Magnetite : Between the Canadian Pacific Railway and Amethyst Harbor, township of McGregor, Thunder Bay district. From a bed showing seven feet and the lower rock not yet reached. It lies in the lower portion of the Animikie rocks. Ontario Government collection.

94. Magnetite : Locations 1 and 2, Herrick's survey, at mouth of Little Pic river on west side, Thunder Bay district. The Canadian Pacific Railway passes through the locations. Ontario Government collection.

95-100. Hematite : Lots 23 to 27, concessions 11 and 12, township of Darling, county of Lanark. James Bell, Arnprior.

101. Magnetite : Atik-Okan range, location 402 R, Thunder Bay district. It is free from injurious combinations, and runs from 63 to over 70 per cent. of iron. The deposit forms a mountain range with the associated Huronian green schists and diorites, rising to an elevation above the surrounding plain of 50 to 125 feet, and extending along the run of the ore for nearly a mile. There are two veins of ore, with 50 feet to 60 feet of slate between, and for a good portion of the distance the veins will aggregate a thickness of 100 feet. South Shore iron experts who have examined the location pronounce it one of the best iron deposits known. H. A. Wiley, Port Arthur.

103-105. Magnetite : Lot 16, concession 9, township of Bagot, county of Renfrew. Ontario Government collection.

106-108. Specular : Lot 29, concession 14, township of Clarendon, county of Frontenac. Large deposit, fully 1,000 tons in sight ; partly developed. Allison & Platt, Adolphustown.

109. Magnetite : Lot 17, concession 10, township of Portland, county of Frontenac. William Pursey, Verona.

110. Magnetic iron sand : Shore of Lake Superior, between White and Cascade rivers. Vein eight inches deep, traced for one thousand feet. F. A. Fenton, Toronto.

160. Magnetite : Lot 27, concession 4, township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

161. Magnetite : Lot 5, concession 6, township of Lutterworth, county of Haliburton. T. D. Ledyard, Toronto.

163. Magnetite : Lot 25, concession 4, township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

165. Limonite : Township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

166. Magnetite : Lots 13 and 14, concession 10, township of Bagot, county of Renfrew.

167. Magnetite : Township of Clarendon, county of Frontenac. Allison & Platt, Adolphustown.

168. Magnetite : Paxton mine, township of Lutterworth, county of Haliburton. T. D. Ledyard, Toronto.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

169. Magnetite : Mountain mine, township or Lake, county of Hastings. R. C. Clute, Belleville.

170. Hematite (specular) : Echo lake, Algoma district. P. C. Campbell, Sault. Ste. Marie.

171. Magnetite : Lot 4, concession 9, township of Palmerston, county of Frontenac. Surface shows 200 by 50 feet. Analyzes 63 per cent. iron, 2.14 per cent. silica, and only traces of phosphorus and sulphur. Ontario Government collection.

172. Magnetite : Wilbur mine, lot 4, concession 12, and lot 4, concession 13, township of Lavant, county of Lanark. Area of deposit, 1,200 feet by 15 feet. Average lots analyze 60 per cent. iron, 6.31 per cent. silica and 009 phosphorus. W. C. Caldwell, Lanark. Ontario Government collection.

174. Magnetite : Iron Duke mine, township of Darling, county of Lanark, five miles from the Kingston and Pembroke Railway. Contains by analysis 65 33 per cent. metallic iron, .017 phosphorus, and no titanium. Extent of location, 3,000 acres. Wylie & Co., Carleton Place.

175. Hematite : Echo lake, East Algoma district. P. C. Campbell, Algoma Mills.

176. Hematite (specular) : Echo lake, East Algoma district. P. C. Campbell, Algoma Mills.

177. Hematite (kidney) : Silver lake, Thunder Bay district. It analyzes 68 to 69 per cent. of metallic iron, with no injurious ingredients in combination ; seems to be in large quantities, but owing to irregularity will require development to show the actual extent ; is the same kind of ore, and is in the same geological horizon as that of the famous Colley mine of the south. shore of lake Superior. It has been explored to a small extent by mining. P. McKellar, Fort William. Ontario Government collection.

178. Magnetite : Lot 25, concession 4, township of Snowdon, county of Haliburton.

179, 180, 184, 187, 191, 192. Magnetite : Belmont mine, township of Belmont, county of Peterborough.

181, 183, 185, 186. Magnetite : Lot 25, concession 4, township of Snowdon, county of Haliburton. Several outcrops of ore on lots 25, 26 and 27, extending at intervals over a space of nearly three quarters of a mile, situated on high ground overlooking the railway track, and ore may be raised and loaded on the cars for one dollar per ton. Analysis of ore from lot 25 gave metallic iron, 62 per cent ; sulphur, .025 ; phosphorus, a trace, and no titanium. From lot 27 gave metallic iron, 62.57 ; phosphorus, .025 ; sulphur and titanium, none. The Irondale, Bancroft and Ottawa Railway runs through lots 25 and 26, and in front of 27, connecting with the Midland branch of the Grand Trunk, about eight miles west of the mines. T. D. Ledyard, Toronto.

188. Hematite : Township of Darling, county of Lanark. Wylie & Co., Carleton Place.

189. Hematite : Township of Madoc, county of Hastings. Mrs. J. A. Wallbridge, Belleville.

190. Hematite : Iron island, Thunder Bay district. Ontario Government collection.

284. Magnetite : Lot 19, concession 1, township of Belmont, county of Peterborough. " A railway is now being constructed to the Belmont mine. It has been estimated that this ore bed contains over 1,000,000 tons of ore within 100 feet of the surface, and the stripping is very light. The ore bed has been thoroughly explored, and of the numerous samples which I have analyzed the above example is a fair average. It will be noticed that this ore equals the best of the famous Swedish Dannemora ore in regard to its low phosphorus contents, contains much less sulphur, and from 10 to 20 per cent. more iron." Wm. Molin in The Engineering and Mining Journal, November 19th, 1892, p. 484. Bessemer Iron Mining Co.

301. Magnetite : Lots 9 and 10 (400 acres), concession 8, township of Bathurst, county of Lanark. Analysis shows metallic iron 65.07, insoluble silicious matter 6.66, soluble silica 44, sulphur .05, phosphoric acid .06, alumina .06, lime .16. John Hart, Perth.

302 Magnetite : Atik-Okan location (see 101), Thunder Bay district. W. W. Russell, Port Arthur.

368. Specular : Township of Loughborough, county of Frontenac. W. G. Kidd collection.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

370. Magnetite : Township of North Crosby, county of Leeds. W. G. Kidd collection.

371. Magnetite : Robertsville mine, township of Palmerston, county of Frontenac. W. G. Kidd collection.

372. Magnetite : Wilson location, township of Lavant, county of Lanark. W. G. Kidd collection.

373. Magnetite : Glendower mine, township of Bedford, county of Frontenac. W. G. Kidd collection.

438. Magnetite : Lot 31, concession 4, township of Snowdon, county of Haliburton. Analysis by Prof. Wm. Molin, New York, shows metallic iron 69.246, phosphorus .012, sulphur .038, titanic acid trace only. T. D. Ledyard, Toronto.

440. Magnetite : Lot 27, concession 4, township of Snowdon, county of Haliburton.

441, 442, 444. Magnetite : Belmont, county of Peterborough.

443, 446. Magnetite : Lot 25, concession 4, township of Snowdon, County of Haliburton. T. D. Ledyard, Toronto.

447. Magnetite : Lot 31, concession 4, township of Snowdon, county of Haliburton. T. D. Ledyard, Toronto.

477. Magnetite : Robertsville mine, township of Palmerston, county of Frontenac. W. G Kidd collection.

478. Magnetite : Glendower mine, Janesville, county of Addington. W. G. Kidd collection.

483. Magnetite in calcite : Robertsville, township of Palmerston, county of Frontenac. W. G. Kidd collection.

579, 581. Magnetite (black Bessemer) : Easterly 90 acres of each of lots 3 and 4, concession 9, township of Palmerston, county of Frontenac. Property known as the Roberts mine, on Kingston & Pembroke Railway, about 60 miles from Kingston. Assay by J. H. Hulbert, Duluth, shows 67.3 of iron, with remarkable freedom from deleterious matter. When the mine was worked, consignments of ore were forwarded to Pittsburgh, Pa., and guaranteed 65 per cent. of iron, free from sulphur. The main shaft is upwards of 300 feet deep, and the ore appears to exist in immense quantities. F. W. Ferguson, Winnipeg, Man.

628. Hematite : Wallace mine, north shore of Lake Huron, Algoma district. Thomas Frood, Little Current P.O., Algoma.

749, 751. Hematite (gray) : Lot 7, concession 10, township of Portland, county of Frontenac. Ontario Government collection.

750. Magnetite : Lot 7, concession 10, township of Portland, county of Frontenac. Ontario Government collection.

752. Bog ore : Lot 28, broken front concession, township of Gainsboro' county of Lincoln. Ontario Government collection.

763. Hematite (deep red and soft) : Lot 7, concession 10, township of Portland, county of Frontenac ; two miles from Kingston & Pembroke Railway. Drill shows a depth of 65 feet. This ore seems well adapted to the manufacture of pigments. Ontario Government collection.

787. Magnetite : Glendower mine, township of Bedford, county of Frontenac. Analysis gives 62 per cent. metallic iron. Good railway connection on Kingston & Pembroke Railway. Ontario Government collection.

788. Magnetite and Hematite: Lot 17, concession 10, township of Portland, county of Frontenac. Ontario Government collection.

Catalogue of the Ontario exhibit of iron ores at the World's Fair.

813. Magnetite: Lot 25, concession 5, township of Darling, county of Lanark. Assay shows from 66 to 68.85 metallic iron, earthy matter 28.524, silica 2.60, phosphorus .026. Robert McGregor, Calabogie.

814. Magnetite: Lot 38, concession 1, township of Clarendon, county of Frontenac. Property has not been worked. Vein from 6 to 10 feet wide; thirteen miles from Lavant station, Kingston & Pembroke Railway. Ontario Government collection.

855. Magnetite (large sample): Atik-Okan location, Thunder Bay district. (See No. 101.) A. L. Russell, Port Arthur.

859. Hematite: Nipigon, Thunder Bay district. Wiley collection.

872 Hematite: Lot 13, concession 9, township of Marmora, county of Hastings.

897. Magnetite: Township of Glamorgan, county of Haliburton. Haliburton Mining Co., Toronto.

908. Magnetite: Coe Hill, township of Wollaston, county of Hastings, on the line of the Central Ontario Railway. The deposit is about 2,000 feet long and over 100 broad, forming a high ridge from which a large quantity of ore has been mined. The analysis gives nearly 70 per cent. of metallic iron, with a small proportion of sulphur, but no titanium. J. D. Riddell, Supt. C. O. R., Trenton.

1064 1076. Magnetite and Hematite: Cabinet specimens from various localities in eastern Ontario. J. L. Aunger collection.

1176. Magnetite: This specimen is part of a boulder found by Mr. William Jenkins of Madoc, within a few miles of that town. It is so strongly magnetic as to constitute loadstone. James F. Boyle, Toronto.

1177. Magnetite: Lot 10, concession 6 (known as "The 49 acres"), township of Madoc, county of Hastings. Mrs. J. A. Wallbridge, Belleville.

1178. Hematite: Lot 12, concession 5, township of Madoc, county of Hastings Mrs. J. A. Wallbridge, Belleville.

1333. Hematite (kidney): S. G. Fogg, Rat Portage.

1423. Hematite: Lot 2, concession 6, township of Sheffield, county of Addington. This mine is three-fourths of a mile from Tamworth, on the Napanee & Kingston Railway. Leonard Wager, Tamworth.

1455, 1472. Magnetite: Gunflint lake, Thunder Bay district. "This is said to be one of the largest and best iron deposits in Ontario. Several analyses show not less than 64 per cent. metallic iron, with freedom from deleterious matters." W. C. Caldwell, Lanark.

1485, 1486. Magnetite: Emily mine, and St. Charles mine, township of Tudor, county of Hastings. Henry Johnson, Coe Hill.

1487. Magnetite: Cameron mine, township of Chandos, county of Peterboro'. Henry Johnson, Coe Hill.

1490. Hematite: Arthur mine, township of Chandos, county of Peterboro' Henry Johnson, Coe Hill.

1492. Hematite: Township of Wollaston, county of Hastings. Henry Johnson, Coe Hill.

1561. Limonite: Echo Bay. Nelson Simmons, Echo Bay.

IV.

TREATING IRON ORES AND METALLIC IRON.

It has been shown that we have iron ores in many localities, east, west and north. We have bog ores, red and brown hematite ores, magnetic ores and carbonate ores. But we have not one working mine in the Province, nor one blast furnace for the smelting of iron ores. The United States is making and using about 9,000,000 gross tons a year, being at the rate of one-seventh of a ton or 320 lb. per head of the country's population. What the consumption is in Canada cannot be so definitely ascertained. A small portion of the whole is produced in the country, the quantity of which is known. The great bulk is imported, chiefly from Great Britain and the United States; part of it as pig iron, but much the larger portion as manufactured goods, or as iron and steel in various stages of manufacture. The Trade Tables of the Dominion classify the imports by articles and values, and to a certain extent by weight also. In so far as the latter classification is given we have a basis upon which to estimate the total quantity of our iron and steel imports, and for the purpose of making such an estimate the following comparative table of quantities and values has been compiled from the trade reports of the Dominion for the fiscal years 1881-2 and 1891-2:

Enquiry into production and consumption.

IMPORTS OF IRON AND STEEL.

Statistics of iron and steel imports.

Articles.	1881-2		1891-2.	
	cwt.	$	cwt.	$
Band and hoop iron	73,860	129,931	92,014	143,853
Bars, rolled, etc	891,494	1,328,610	133,353	231,468
Plates and sheets	271,805	714,187	442,038	1,067,027
Carwheels and forgings	27,326	74,492	25,541	105,036
Chain cables	31,084	79,103	23,803	63,263
Slabs, blooms, etc	203,888	222,056	64,397	56,186
Bridge and structural iron	49,664	212,527	6,018	27,363
Nails and spikes	11,382	51,217	9,871	40,276
Scrap iron and steel	26,545	20,406	740,687	507,018
Pig iron	1,268,620	1,023,012	1,378,360	886,485
Railway iron (rails, fish plates, etc.)	117,667	184,459	126,320	189,199
Rolled beams, etc	41,921	83,852	153,510	220,287
Nail and spike rods	16,661	24,806	16,795	36,090
Wire	121,328	455,464	72,149	219,643
Locomotive tires	8,943	45,180	27,609	86,294
Iron and steel for ships	8.978	45,819	36,703	70,663
Steel ingots, bars, etc	328,382	895,857	159,994	421,530
Steel rails	2,279,959	3,531,330	1,654,935	1,738,661
Steel for manufacturers	1,002	5,074	45,683	180,901
Totals	5,780,509	9,127,382	5,209,780	6,291,243

The average value per net ton in the first of those years would therefore be $31 58, and in the second $24 15 In 1881-2 the total value of our imports of iron and steel was $17,075,588, and in 1891-2 it was $12,641,442.[1]

Averages of value.

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[1] In 1881-2 the value of dutiable iron and steel was $12,301,974, upon which the duty levied was $2,593,994.04, or 21 per cent. The value of the free was $4,773,614. In 1891-2 the value of the dutiable was $9,968,409, upon which the duty levied was $2,792,088.12, or 28 per cent. The value of the free was $2,673,033. The decrease in values of the Canadian imports

Pig iron equivalent of consumption.

Consumption per capita.

Assuming the average values per ton to be the same as those deduced from the table, the total quantity imported in 1881-2 would be 540,709 net tons, and in 1891-2 it would be 523,455 tons. Of these quantities pig iron constituted only 63,431 tons in 1881-2, and only 68,918 tons in 1891-2, the balance in the respective years being manufactured or partly manufactured iron and steel. In order therefore to make a fair comparative estimate of consumption per head of population, allowance should be made for waste in the refining of pig iron when remelted for making cast or rolled iron and for conversion into steel. Sir Lowthian Bell estimates the waste in the conversion of pig iron into steel by the basic process at 25 to 30 per cent., and by the ordinary Bessemer process at 12 per cent.[2] But of course the rate of waste will vary with the qualities of iron treated, and also no doubt with the processes used. If we take an average waste of 10 per cent., which I think is very moderate, the iron and steel imported into Canada in the manufactured and partly manufactured state will represent an equivalent in pig iron for 1881-2 of 530,310 tons, and in 1891-2 of 505,040 tons. In the first of these years the quantity of pig iron made in Canada was about 25,000 tons, and in the second it was 30,294 tons. Add the quantity which was imported as pig iron in the respective years, and the total consumption of the country would be the equivalent of 618,741 net tons of pig iron in 1881-2 and 604,252 tons in 1891-2, or at the rate of 288 lb. per head of population in the former and 252 lb. in the latter year. If the waste by conversion was taken as 15 per cent. the average consumption per head in the first named year would be 302 lb and the second 264 lb[3] But this rate of consumption is not uniform over the whole of Canada. In the more prosperous sections it will be highest, unless there should be exceptional circumstances, like

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of iron and steel is a consequence of the fall which has taken place in prices in the countries of production. An average of quotations of pig iron given in the London Iron for six months ending December 31 of 1881 and 1891 shows that the price of Scotch warrants (Glasgow) in the former period was 49s. 8¼d. and of Cleveland warrants (Middlesboro') 40s. 8d., and in the latter period 47s. 3d. and 40s. 0½d. per ton respectively. Scotch pig therefore fell only 4 per cent. in the ten years and English pig only 1⅓ per cent. But the decline in steel was much greater, the average of quotations for steel bars (Bessemer or Siemens-Martin) at the works being for the former period £9 to £10 and for the latter £6 13s. 4d. to £7 1s. 8d. per ton, or a fall of 27⅔ per cent. This is a result due partly to increase in competition, but largely also to the more general adoption of improved processes in the manufacture of steel. Sir Henry Bessemer's process has indeed wrought a revolution in prices. When his patent was taken out in 1855 the price of steel in Great Britain was $250 per ton, and the annual production was only 50,000 tons. Thirty-two years ago, when his works were started at Sheffield, steel rails sold at $115 to $120 per ton, and in 1888 they had fallen to $20. The first Bessemer rails were made in the United States in 1867, and the selling price in Philadelphia was then $166 per ton ; five years later, when production had risen in that country to 120,000 tons, the selling price was $112 per ton. In 1874 it fell in Philadelphia to $94, in 1878 to $42.25, and in 1885 to $28.50. This great lowering of price is a result accomplished by the invention of Sir Henry Bessemer, and the outcry against the late Alexander Mackenzie for purchasing steel rails in a falling market is worth recalling in connection with it. As showing the progress made in the manufacture of steel, it may be stated that while in 1877 the total production of Bessemer steel ingots in Great Britain and the United States was 1,250,524 gross tons, it had risen in 1890 to 5,733,714 tons. But the two countries had also in the latter year produced in addition 2,139,020 tons of open-hearth steel.

[2] Principles of the Manufacture of Iron and Steel, pp. 411-12. In Carroll D. Wright's Report on the Production of Iron, Steel, Coal, etc.. (sixth Report of the U. S Commissioner of Labor) the waste in making finished bar iron, computed from records of twenty establishments, is found to be 18¼ per cent , the average loss in making a gross ton being 482 lb. The materials used were muck bar, scrap, pig iron, and in six cases a small quantity of iron ore ; but the bulk of the material was muck bar (p. 126). The waste in making steel ingots, chiefly from pig iron, computed from the records of eight establishments in the United States, seven in Great Britain and five in Europe, is 318 lb., or 12½ per cent. (p. 154) And in making steel rails from ingots, blooms and billets, the records of two establishments in the United States, three in Europe and three in Great Britain show a loss by waste of 348 lb. in the production of a gross ton, or 13½ per cent. (p. 165) At every stage in the manufacture of iron and in every heating of it there is inevitable waste of material.

[3] The higher rate of consumption in 1881-2 is due in part to the supplies of steel rails, fish plates, spikes, etc., imported that year free for original construction of the Canadian Pacific Railway. But the whole of this quantity was only 34,797 tons, or 16 lb. per head of the population, and with this allowance made the excess of consumption in 1881-2 over 1891-2 is still 20 lb. per head (or 22 lb. if loss by waste is calculated at 15 per cent.) It will be remembered however that 1881-2 was a year of boom.

railway construction, to create abnormal demand in the poorer or more sparsely settled districts. Our wants in Ontario can hardly be less than those of the average United States citizen ; the probability is that they are higher, since there are few States of the American Union as wealthy as this Province, or in which the requirements of industrial and commercial life are as great. Instead therefore of a present requirement of 252 lb. per head of population, it may be assumed that our yearly consumption is not less than 320 lb. ; so that the total for the Province is 300,000 gross or 336,000 net tons of pig iron or its equivalent, every pound of which that is not supplied by Quebec and Nova Scotia furnaces is the product of foreign labor. The great bulk of this iron too, as has been shown, reaches us in the manufactured state ; only a small proportion of the whole, less than 12 per cent., is brought in as pig iron (a small part of which is cast scrap), and less than one per cent. of it in the form of slabs, blooms, loops and billets. The import of wrought scrap of iron and steel, upon which the rate of duty is only half of the rate imposed on pig iron, has increased in the ten years from 1,327 to 37,034 tons, (equal to 41,150 tons of pig iron, allowing for waste in conversion), so that the quantity of it now used by our rolling mills and foundries is more than all the pig iron smelted in the country. Taking the pig iron and the wrought scrap together, it is the equivalent of 110,068 tons of pig. This is a quantity sufficient if made in Canada to employ five furnaces having the capacity of the Londonderry Iron Company's furnace working at its average of the past nine years, or seven furnaces having a capacity of 50 tons per day and running for 300 days in the year. But it must be admitted that this is a long campaign, to be carried on continuously year after year. In Sweden, where all the pig iron is a product of charcoal furnaces, the average is much shorter, as the following statistics of production for the five years 1886-90 will show :

The bulk of iron imported in the manufactured state.

Imports of pig and scrap iron.

The example of Sweden.

——	1886.	1887.	1888.	1889.	1890.
Furnaces in blast	161	164	162	150	154
Pig iron made, metric tons	442,457	456,625	457,052	420,665	456,102
Total time for all furnaces in blast, days	39,777	40,582	39,840	35,859	37,892
Average daily product per furnace, tons	11.12	11.23	11.47	11.73	12.04
Average time per furnace in blast, days	242.5	247.5	246	239	246

The average campaign of charcoal furnaces in Sweden therefore is only 244 days, ranging in the five years from 242½ to 247½ days a year ; and it would require 39 furnaces of the same capacity, running for the same average time, to smelt the pig iron with its equivalent of scrap which is now used in this Province. But the capacity of furnaces aside, there surely is here an opening for iron making in Ontario if all the conditions exist which favor production on advantageous terms. Iron manufactures of various kinds have been carried on for many years in almost all our towns and cities ; but the raw material has come from outside sources, with its cost enhanced to manufacturers and consumers by duties, freights and commissions. If it were made at home as cheaply and of as good quality as it can be supplied by the iron masters of the United States and Great Britain it would unquestionably be a great boon, resulting in the opening up of our iron mines, the utilization of our timber for charcoal fuel, the employment of labor, and, it is to be hoped, in the profitable investment of capital. And as the industry became established and strengthened, cost of production would be lowered, iron manufactures would increase in variety and volume, and by degrees Ontario and the whole of Canada might become, as regards the iron industry, a self-contained country.

Advantages of producing the raw material at home.

QUANTITY AND QUALITY OF ORES.

No prudent man is likely to take an interest in iron mining or iron making without first satisfying himself that ores can be procured at points convenient for shipment in sufficient quantities and of suitable qualities for the supply of a furnace.

Evidence of supplies of ores in

In so far as quantities are concerned, it is believed that we have an abundance in Ontario. Indeed the evidence of scientific and practical men, who may be presumed to speak with authority, is that we have an overflowing abundance of ores of different kinds, but the magnetic ore chiefly, owing to the occurrence of this variety in the Archæan rocks. Yet it is never absolutely safe to depend upon surface indications of quantity, and the cautious man would require such further proofs as actual workings or diamond drill explorations can alone in many cases afford. Where a range of ore rises to a great height above the general level of the country and may be traced by exposures for long distances, as in the case of the Atik-Okan and Mattawan, or where level beds are observed extending over large areas, as in the case of the Mesabi, in the northwestern part of the Province, the question of supply can hardly be raised. In the eastern part of the Province however the shows of iron ore occur on a less gigantic scale, and although some of them are proven to be large bodies there are others in which the quantity is very doubtful. There are known cases indeed which in what appeared to be a large deposit turned out to be a mere surface show, to the serious disappointment and loss of parties who had purchased the property. Mining engineers of reputation employed in directing the opening up of veins of gold, silver, nickel, copper and other ores will seldom counsel the building of expensive reduction works until enough ore has been mined to pay for working expenses and cost of the works; and this is safe counsel to follow also in dealing with iron mines and blast furnaces.

northwestern and eastern Ontario.

An unfortunate experience as regards quality.

As regards quality, it has to be confessed that our ores do not enjoy a high reputation with furnace men, especially in the United States. It is true that they have not been tested in large quantity, nor from many mines; but most of the shipments made were unfortunate, being chiefly hard magnetites and high in titanium like the ore of the Chaffey mine, or high in sulphur like the ores of the Glendower and Coe Hill mines. The unsuccessful attempts at iron making in the Province too have added their weight to the suspicion. And so, to use a phrase familiar to iron men, Ontario ores have received a "black eye." In the United States the magnetic ores are also largely impure, being found in some localities high in titanium, in others high in phosphorus, and in others high in sulphur; and as a result of discoveries of very large bodies of clean hematite or specular ores in Michigan, Wisconsin and Minnesota, smaller relative quantities of magnetic ore are used in blast furnaces in that country now than formerly. In 1880 the total output of the iron mines of the United States was 7,120,362 gross tons, of which 2,243,993 tons was red hematite and 3,134,276 tons was magnetite. In 1889 the total production had risen to 14,518,041 tons, whereof 9,056,288 tons was red hematite and only 2,506,415 tons was magnetite, or 62.38 per cent. of the former and 17.26 of the latter. Of other ores, 17.38 per cent. of the whole was brown hematite and 2.98 per cent. carbonate ore. During the decade red hematite had risen from 31.52 to 62.38 per cent, and magnetic ore had fallen from 29.97 to 17.26.[4]

Impure magnetic ores of the United States.

Relative consumption of ores in the States.

MECHANICAL TREATMENT OF ORES.

Enriching and cleaning ores at the mines.

In a number of instances, Mr. Birkinbine says in the last census report, the ores are treated at the mines to enrich them. Most of the carbonate ores are roasted to drive off the carbonic acid and the sulphurous ores to drive off the sulphur, while some of the brown hematites are roasted to facilitate the crushing of lumps or to drive off an excess of water. Washing appliances are used at most of the brown hematite mines to remove clay, sand, etc., from the ores before they are shipped to the furnaces, while jigs are employed to a limited extent for cleaning red hematites and magnetites. "The year 1889," Mr. Birkinbine says, "marked a revival in magnetic concentration, whereby ores carrying smaller percentages of iron than would pay for their exploitation and shipment, or iron ores which have an excess of phosphorus as apatite, or of sulphur in the shape of pyrites, are granulated and passed over various forms of apparatuses in which are currents of electricity or fixed magnets to attract the magnetic material, allowing the non-magnetic to pass away as tailings. This revival in 1889 was confined largely to the construction and equipment of plants for treating ores on a liberal scale, or experiments with various machines under different conditions. As a result of this the amount of such ore produced was small, but subsequently the completion of plants, aggregating a cost of over $500,000, their operation and the results of experiments, made this feature an important one, and one which will probably grow with each year."[5] The amount of iron ore passed through water jigs or magnetic separators in 1889 was 95,425 gross tons, and in 1891 the quantity increased to 98,546 tons of magnetically separated ore and 110,777 tons of jigged ore. In this last year there were 62 magnetic separators in operation in the United States, including machines of the three following classes: (1) Those in which the trajectory of falling material is altered by introducing the attraction of a magnet, to draw the magnetic portion away from the non-magnetic (2) Those wherein the ore is fed to a revolving drum or drums in which is a magnet core, the shells of the drum being either of alternate magnetic and non magnetic strips or entirely of magnetic or non-magnetic material. (3) Belt machines, in which the ore is fed to a belt or series of belts passing under or over magnets or magnetic drums, the machines working sometimes in water and sometimes dry. "There is apparently a wide field for magnetic separation," Mr. Birkinbine says, "especially in the States of New York, New Jersey, Pennsylvania, Virginia, North Carolina and Michigan, where there are large deposits of lean magnetic ores. At first there was considerable prejudice against the use of concentrated ore by some of the blast furnace managers, but this has been largely overcome by practice, which has proven that properly concentrated ore contributes to the good working of the furnace, and in the future this class of ore may be used largely in place of some of the higher-priced ore brought to eastern blast furnaces. This class of ore has also been used in most of the direct processes, and any development of these processes will encourage a corresponding demand for concentrates."[6] It is calculated that the average yield of metal from iron ores mined in the United States in 1880 was 51.22 per cent., and in 1889 51.27 per cent. This is not a high average, or at least it would not be so regarded where, as in Ontario, magnetic ores run up from 60 to 70 per cent. of metallic iron, and even higher; and doubtless it will have the effect of encouraging an enrichment and cleansing of ores by sorting, separating and concentration.

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[4] Report on Mineral Industries in the United States at the Eleventh Census, 1890, p. 7.

Magnetic concentration of ores.

Classes of magnetic separators in use.

A large field for separators.

Average percentage of metallic iron in United States ores.

TREATMENT OF ORES IN GREAT BRITAIN.

In Great Britain even more than in the United States the impure quality of the ores makes preliminary treatment a necessity. The clay ironstone or carbonate ore which is so abundant in that country is almost all calcined to drive off the carbonic acid and water, as well as portions of sulphur which it may contain; and when so treated it yields only about 30 per cent. of metal. In the case of phosphorus it is quite exceptional, Sir Lowthian Bell observes, when any material treated in a blast furnace is abso-

Calcining the carbonate ore.

General prevalence of phosphorus.

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[5] Report on Mineral Industries in the United States at the Eleventh Census, 1890, p 12.

[6] Mineral Resources of the United States, 1891, p. 43.

lutely free from it; the fuel, flux and ore all appear to contain it in greater or less quantities. "Beginning with the oxides of iron found in the granite formation and ending with the lake ore forming at the present day, this element is almost invariably present. It occurs almost always combined with oxygen as phosphoric acid, in the form of phosphates of iron or lime in the ore, or as phosphate of lime in the flux and fuel. When a phosphate of iron or lime is exposed to a high temperature in contact with carbon the oxygen is separated from these salts and the product is phosphide of iron or phosphide of calcium. The pig iron then dissolves the phosphide of iron, or decomposes most of the phosphide of calcium. Thus it unfortunately happens that by far the largest quantity of this substance, as it occurs in the materials, is taken up by the iron."[7] In this way it happens that of the whole of the phosphorus existing in the materials not less than 90 per cent., it is calculated, finds its way into the iron.

THE INJURIOUS ELEMENTS IN IRON.

Ontario ores not exceptional.

It is evident therefore that in other countries as well as in Ontario the iron ores are impure and give rise to difficulties which are not easily overcome. But the fact that they are overcome in a large measure and that new and improved processes are being tested and introduced from time to time strengthens the belief that there is nothing in the character or quality of our Ontario ores to cause them to be regarded as in any material respect inferior to ores elsewhere.

Titanium.

Phosphorus and its effects.

Of the three most injurious elements, viz: phosphorus, sulphur and titanium, the first named is not usually found to exist in injurious proportions in iron ores of the Archæan rocks, while the last named does not as a rule occur in combination with either of the other two. Phosphorus is objected to because it makes iron "cold-short," that is to say it is brittle when cold. It is the steel-maker's bane. "Phosphoric iron," Howe says, "is readily broken by jerky, shock-like or vibratory stresses, sometimes when quite trifling; it is treacherous. It sometimes affects iron but slightly, sometimes under apparently like conditions profoundly; it is capricious. It unusually increases the elastic limit, thus raising the elastic ratio, an index of brittleness. It diminishes also the elongation and contraction on rupture, two other measures of ductility affecting this property like tensile strength much more under shock than under quiescent stress."[8] One of its most obvious physical effects is to induce in iron or steel a coarsely crystalline structure, and this is supposed to be the cause of brittleness in the metal.

Effect of sulphur in iron.

The effect of sulphur is to produce "red-shortness" in iron or steel, that is to say brittleness at a red heat, while for the foundry it hardens the metal. "It is thought to make malleable iron slightly tougher and softer when cold but to make cast iron harder, though this latter effect is at least in part due to its causing it to retain the carbon in the combined state. It increases the fusibility of cast iron, but makes it thick and sluggish when molten and gives rise to blow holes during its solidification."[9] Its action is generally most noticeable at a dull red heat, but when present in only small quantity the iron is readily forged at high temperatures. If however the percentage is high the iron is no longer malleable at high temperatures.

Effect of titanium.

One serious objection to titanium, upon which all authorities are agreed, is that it gives rise to a pasty and viscous slag in the blast furnace, which, besides being non flowable when tapped, forms "bridges" in the furnace which interfere with its working. But as to its effect on the quality of iron, opinions differ. By some it is said to give hardness, toughness and strength to the metal, and that under no circumstance is the iron "cold short" or "red-short." Other authorities again, like Howe, while admitting that it often occurs in gray soft iron, affirm that the metal is so oxidizable as to make it a matter of extreme doubt if it ever exists in wrought iron or steel.[10]

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[7] Principles of the Manufacture of Iron and Steel, p. 165.

[8] The Metallurgy of Steel by Henry Marion Howe, p. 54.

[9] Ib. p. 49.

Recent improvements in methods of treating ores and metallic iron.

Some of the methods of treating iron ores and metallic iron containing those hurtful elements are old and well known, while others are of recent adoption and have barely passed the experimental stage. Cobbing, roasting and washing are methods easily applied to all ores, and lime is an excellent agent in carrying off a percentage of sulphur when used as flux in the charge of a blast furnace. Magnetic separators are only useful when applied to magnetic ores which have been reduced to powder by crushing or milling. They not only enrich the ores by separating the earthy or rock matter from the oxide of iron, but also by separating such parts of phosphorus, sulphur and titanium as are not chemically united with the oxide of iron, which sometimes is a large percentage of the whole. Machines of various designs, as already shown, have been constructed for this purpose, and some of them appear to be well fitted for doing their work effectively and economically. But most of them are of recent invention, and doubtless their working will suggest important improvements both in utility and in economy.[11]

SMELTING TITANIC ORES.

Rossi's investigations and experiments.

Experiments conducted last year with titaniferous ores by Auguste J. Rossi of New York afford grounds of assurance that the titanium difficulty may further be overcome in blast furnace practice. Mr Rossi learned that ores of this class containing from 10 to 20 per cent. of titanic acid had been successfully smelted in large quantity in the Adirondack mountains, in New

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[10] On page 85 of his valuable work on the Metallurgy of Steel Mr. Howe says titanium can probably only be introduced into any malleable variety of iron by a tour de force, nor is there reason to believe that if introduced it would be beneficial. On page 369 he refers to two samples containing a small proportion of titanium, but having a high percentage of carbon. By others it is claimed that the titanium may have an excellent indirect beneficial effect on wrought iron and steel, even when little or none of it is found in them, when they are the product of pig iron smelted from titaniferous ores.

[11] An interview with Thomas Edison in McClure's Magazine for June, 1893, pp. 37-8, under the title of Unsolved Problems that Edison is Studying, gives the following interesting account of the attention which that inventor is giving to the perfecting of his methods for treating lean or impure magnetic iron ores: "The most important of the campaigns I have in mind is one in which I have now been engaged for several years. I have long been satisfied that it was possible to invent an ore-concentrator which would vastly simplify the prevailing methods of extracting iron from earth and rock, and which would do it so much cheaper than those processes as to command the market. Of course I refer to magnetic iron ore. Some of the New Jersey mountains contain practically inexhaustible stores of this magnetic ore, but it has been expensive to mine. I was able to secure mining options upon nearly all these properties, and then I began the campaign of developing an ore-concentrator which would make these deposits profitably available. This iron is unlike any other iron ore. It takes four tons of the ore to produce one ton of pure iron, and yet I saw some years ago that if some method of extracting this ore could be devised, and the mines controlled, an enormously profitable business would be developed, and yet a cheaper iron ore—cheaper in its first cost—would be put upon the market. I worked very hard upon this problem, and in one sense successfully, for I have been able by my methods to extract this magnetic iron ore at a comparatively small cost, and deliver from my mills pure iron bricklets. Yet I have not been satisfied with the methods; and some months ago I decided to abandon the old methods and to undertake to do this work by an entirely new system. I had some ten important details to master before I could get a perfect machine, and I have already mastered eight of them. Only two remain to be solved; and when this work is complete I shall have I think a plant and mining privileges which will outrank the incandescent lamp as a commercial venture, certainly so far as I am myself concerned. Whetever the profits are, I shall myself control them, as I have taken no capitalists in with me in this scheme."

'Mr. Edison was asked if he was willing to be more explicit respecting this invention, but he declined to be, further than to say':

"When the machinery is done as I expect to develop it, it will be capable of handling twenty thousand tons of iron ore a day, with two shifts a day, five men in a shift. That is to say ten workmen, working twenty hours a day in the aggregate, will be able to take this ore, crush it, reduce it to cement-like proportions, extract it from the rock and earth, and make it into bricklets of pure iron, and do it so cheaply that it will command the market for magnetic iron."

When Mr. Edison speaks of "pure iron" in the last sentence, he no doubt means pure oxide of iron.

Aim of his experiments.

Laboratory tests for flux.

General results.

York State, some fifty years ago, and after as full an investigation of the records of those furnaces as was available, he proceeded to make laboratory tests along the same lines. The success of the furnaces appeared to have been due largely if not wholly to the use of certain kinds of flux in the charge which give fluidity to the slag, and the problem seemed to Mr Rossi to be, to produce with titanic acid a slag fully as fusible as those admissible in blast furnace practice. In carrying out his line of experiments the aim was to operate at not too high a temperature, so that if sufficient fusible and fluid compounds could be obtained in the crucible they might then be reproduced in a blast furnace with still greater ease. Some of the experiments were made with ores, but whenever it was intended to work for a certain type of titanate no ore was used. "Titanic acid was furnished by rutile completely analysed beforehand, and the bases were supplied by adding caustic lime, magnesia, alumina and silica, chemically pure, tested each time before weighing them for such water or carbonic acid as might have been absorbed in the intervals of two experiments by some of the chemicals, such as caustic lime and silica." These bases tested in various proportions gave slags of varying qualities, careful analyses of which were made and recorded. The ores, fluxes and fuel were intimately mixed in the crucibles, having been previously reduced to powder. The results varied much according to the mixtures. In some a good liquid slag was obtained which ran out freely, while others were pasty, chilling quickly and being sluggish and lumpy in flow. Among the general results noticed were, (1) that the presence of a large quantity of magnesia and lime, without alumina, tends to diminish the fusibility, and the addition of alumina renders the slag more fusible and fluid, and (2) that the absence of magnesia, if the percentage of alumina and lime be high, with only five per cent. of silica, has a similar effect on the fusibility, the addition of magnesia increasing the fusibility and fluidity.

Testing the results in a blast furnace.

Capacity of the test furnace.

The question which then arose in the mind of the experimenter was, Could such slags be reproduced in the conditions of working of a blast furnace? Could like compounds be obtained and the iron of the ore be separated from its gangue when the materials were charged into the furnace in lumps and by distinct layers as is the common practice, instead of previously being reduced to powder and intimately mixed as was done in the laboratory? "Nothing but a direct experiment being capable of deciding this question," Mr. Rossi says, "we built a small furnace for the purpose, assuming that if, even on such limited scale with a blast hardly at 300° or 400° F. and a pressure of not over two pounds, we could obtain the calculated slags from highly titaniferous ores with no other flux than limestone (dolomitic), the materials being charged in lumps, in proper relative proportions and in layers at regular intervals, and at the same time obtain pig iron, it would be possible in industrial practice, with a better distribution of heat, a greater height of furnace insuring a complete and thorough reduction of ores, to obtain results of the same kind and even much more favorable. Slags of a more extreme composition or basicity, for instance, though found less fusible in our experiments, might become admissible, though neither advantageous nor neccessary." Accordingly a small furnace was built and tested with a view of proving upon a large scale the results obtained in the laboratory; but as this furnace was only 9 feet in height, with hearth of 12 inches and bosh of 28 inches diameter, it could not be expected to show working of a very satisfactory character. With a light charge of ore in the stack it was only natural that the iron should lose its liquidity in the small hearth; and this is just what did happen, for after rising to the tap-hole it chilled on the run. The slags however kept very fluid from the first tapping, flowing freely on the run to 10 feet from the furnace without chilling, and so continued as long as the blast was maintained. "We do not claim that everything has been settled definitely by this experiment. But it has been possible to obtain from ores

What is claimed for the furnace test.

containing some 20 per cent. of TiO_2 in a continuous manner, under the conditions of working of a furnace and on a scale certainly unfavorable to good reduction of the ores and a proper distribution of heat in the different parts, both slags and pig iron. The slags showed good fluidity and fusibility, though containing, some, $25TiO_2$ to $22SiO_2$; others $40TiO_2$ to $22SiO_2$, and some $35TiO_2$ to $14SiO_2$, with magnesia, alumina and lime as bases. No other addition of fluxes to the ores and coke was required than limestone (dolomite and calcite mixed, pure lime having been once resorted to for want of calcite); and the consumption of materials (certainly of flux, and even of coke, considering the dimensions of the furnace), was fairly economical for a 51 per cent. iron ore, viz., ore 50, coke 50, stone 21."[12]

Importance of the experiments.

Two considerations should lead us to attach great importance to the tests made by Mr. Rossi, especially in view of the success which appears to have attended them. One is, the vast bodies of titanic ores in Canada and the United States, which are at present valueless owing to the hitherto insuperable difficulties of treating them in the blast furnace. The other is, that while many of such ores are found to be rich in iron they are generally free from phosphorus, and frequently also from sulphur.

ELIMINATION OF PHOSPHORUS.

Introduction of the basic process.

Production of Thomas steel.

Value of the slag as a fertilizer.

The presence of phosphorus in iron threatened for a time to defeat the process of Sir Henry Bessemer for the conversion of iron into steel. Even so low a proportion as one thousandth to two-thousandths of one per cent. suffices to make iron or steel "cold-short," and most of the British ores carry phosphorus. In 1872, seventeen years after the date of Bessemer's invention, Mr. Snelus tried the plan of lining a converter with lime, the effect of which was to reduce the phosphorus in the pig iron; but for some cause he failed to prosecute his experiments. The idea was taken up a few years later by Messrs. Thomas and Gilchrist, two young science students of London, and by using a mixture of magnesia and lime for the lining they obtained gratifying results. But where the proportion of phosphorus was high in the iron it was found that the lining alone was not sufficient to carry out the work of dephosphorization. Accordingly they added a quantity of lime to the charge, and so improved the operation as to succeed in removing 96 per cent. and over of the phosphorus initially present. This is known as the basic process, in which dolomite, a basic earth, is used for the lining, to distinguish it from the acid or common Bessemer process, in which silica is the material used for the lining. In America the basic process has not met with much favor, owing it may be supposed to two causes—one being the comparative purity of the ores, and the other the royalty charge for the use of the process.[13] The total quantity of Thomas steel produced since its manufacture was initiated is by latest accounts 19,532,000 tons, whereof 11,452,000 tons is credited to Germany. The total output of Thomas steel last year was 3,202,000 tons, of which quantity Germany and Luxemburg produced 2,013,000 tons. A valuable bye-product of this process is the slag, which consists chiefly of lime and phosphoric anhydride, both of which are valuable fertilizers. The quantity of slag made in 1889 was 600,000 tons according to Gilchrist, and it contains 17 per cent. of phosphoric anhydride and 60 per cent. of lime, which sold at 20s. to 30s. per ton at the works. For sour, peaty and clay soils it is a fertilizer of great value, but for calcareous soil it is not valuable. "It is interesting to note," Prof. Roberts-Austen says, "that the phosphoric anhydride is combined with the lime in an unusual manner. Instead of being an insoluble tri-basic phosphate, it is a readily soluble tetrabasic phosphate, and if it be finely ground the phosphorus it contains is readily assimilated by plants. At first attempts were made to treat it by various chemical methods, but it has been found best to simply grind and use it in fine powder."[14]

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[12] Mr. Rossi's paper giving an account of his experiments with titaniferous ores was read at the meeting of the American Institute of Mining Engineers held at Montreal in February of this year.

[13] The Thomas-Gilchrist patents expire next year, when a considerable development of production by their process is looked for; indeed is feared. Mr Thomas died a few years ago; but Mr. Gilchrist, who is not yet forty years of age, is said to be a millionaire in pounds sterling.

The basic process, it may be observed, is applied to the refining of pig iron, and mainly for its conversion into steel.

No method of eliminating phosphorus from the ore in the blast furnace has yet been discovered; and as to the preparatory treatment of ores containing phosphorus the magnetic separator has no doubt given the best results.

DESULPHURIZING METALLIC IRON.

The puddling process.

There are various porcesses for desulphurizing iron ores, as has been pointed out; and in the furnace a generous use of lime is highly serviceable. By puddling and by the basic process, which are essentially the same, sulphur is expelled from iron, and manganese is also a powerful agent for its removal. Bnt after all these processes have been tried a residuum of sulphur often remains. It is not merely the sulphur in the iron ore which has to be combatted, but the sulphur in the coal or coke as well, whereby the percentage in the pig or cast iron is increased; and various devices have been tried by metallurgists to get rid of it. The importance of obtaining a suitable method has indeed become more pressing than ever before, owing to the more general use of steel which followed the introduction of the Bessemer process. During recent years a special study of the desulphurization of iron has been made, and careful experiments have been carried on by a number of well known men upon scientific lines; but while some progress has been attained there are only two processes which deserve special mention here, and both treat the iron after it has been reduced from its ore.

Growing demand for better processes.

Operation of the Hoerde process.

One of these is the invention of Joseph Massenez, a German, and is known as the Hoerde process because it was first tested on a large scale at that place. It aims at the removal of sulphur from iron by the agency of manganese—iron high in sulphur and poor in manganese being mixed with iron containing a large percentage of manganese and little sulphur. The result is that the manganese of the one charge acts upon and combines with the sulphur of the other, forming a manganese sulphide which rises and flows off in the slag.[15] The mixer is a vessel with a capacity of 120 tons, into one end of which the molten pig iron is poured as brought direct from the blast furnaces, along with a certain amount of ferro-manganese, while from the other end the desulphurized metal is poured into ladles and taken to the Bessemer converters which are used in conjunction with the process. About 1.7 per cent. of manganese is added to the charge, whereof 0.2 per cent. combines with the sulphur, the rest remaining in the iron. One effect of the mixing, it is claimed, is to give steel of more even quality when the operation is completed in the converters. The process appears to be well approved in Germany, and it has recently been adopted in two of the largest steel-making establishments in Great Britain.

Operation of the Saniter process.

The other process to which reference has been made, a later than the Hoerde, is the invention of Ernest H. Saniter, chemist of the Wigan Coal and Iron Co. of England. It is thus described by Mr. Saniter himself:

"A mixture of calcium chloride and lime is prepared, which will fuse readily at the temperature of the iron to be operated upon. The desired combination is made by grinding calcium chloride and lime together in a mill so as to thoroughly mix them, and also to bring them to a moderately fine powder. About equal parts of each are required to give the desired fusibility. This mixture is then placed on the bottom of a ladle or receiver, and consolidated by heat, or kept in position by other suitable means. The heat may be applied in the first instance by means of a blow-pipe arrangement, using blast-furnace gas, but when in continuous use the heat of the ladle itself is quite sufficient. The receiver is then filled with iron, which may be drawn direct from the blast furnace, the heat of which melts the mixture, and the latter, rising up through the metal, removes the sulphur very completely. I do not find it necessary to have reducing conditions, and indeed oxidation may be going on concurrently with the removal of the sulphur, as will be seen later on. Notwithstanding this however the sulphur is removed as sulphide. Should it be desirable to remove silicon as well as sulphur, the lime of the mixture is replaced by hydrate or carbonate of lime, or even oxide of iron in addition should the hydrate or carbonate be insufficient. About 25 lb. of chloride of calcium and an equal weight of lime per ton of iron have been found sufficient to effect purification "[16]

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[14] An Introduction to the Study of Metallurgy, p. 224.

[15] J. E. Stead in the Journal of the Iron and Steel Institute No. II. 1892, p. 258.

For removing silicon as well as sulphur.

Results obtained.

In a number of experiments made with the Saniter process it was found that 73.6 per cent of the sulphur and 35.77 per cent. of the silicon contained in the iron were eliminated, and the whole cost of materials was only twelve cents per ton. The process was carefully investigated last year by Mr. Stead and the results as given by Mr. Saniter were fully confirmed by him, as set forth in a lengthy paper read before the Iron and Steel Institute at its Liverpool meeting of September last year.

Further tests of the Saniter process.

At the meeting of the Institute held in London on the 25th and 26th of May of the current year Saniter's process was again the chief subject of consideration, when papers on it were read by Messrs. Stead and Saniter. Mr. Stead's paper was occupied largely in meeting German criticisms of the process; for it is to be observed that in Germany, according to some metallurgical authorities, the process meets with difficulties in practical use which are not present in the Hoerde method.

Plant for operating the process.

Mr. Saniter's short paper reaffirmed the results previously obtained after six months' further experience of the process. The Wigan Coal and Iron Company, with whom Mr. Saniter is employed, has laid down a plant for dealing with the whole make of a blast furnace, the general arrangements of which are that the sand bed has been lowered to the ground level, whereon and in front of the blast furnace is a ladle on a carriage, the ladle being provided with tipping gear. The ladle is heated before the first operation and the mixture of calcium chloride and lime is put on the bottom, protected with a small cast iron plate to prevent the molten metal cutting under it. The metal is then run in and as soon as the reaction ceases it is tipped into the lowered sand bed and the slag is raked out of the ladle. The quantity treated at a cast is nine to twelve tons, the cost of the plant is under £250 per furnace, and the cost of materials is 4*d.* and of other cost including labor and grinding 2*d.* per ton of iron treated.

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[16] Journal of the Iron and Steel Institute, No. II. 1892, pp. 217-18. The London Engineer of May 5, 1893, writing of Saniter's method says:

"In point of cost—and the commercial aspect of an invention must always override all others—the new process compares very favorably with the Massenez process, which may be considered its principal if not its only rival. The cost of the materials used in the former case appears to be from 6*d* to 9*d*. per ton of pig iron, or 1*s*. per ton including royalty and labor, as against from 1*s*. 6*d*. to 2*s*. 6*d*. for materials only in the latter case. The cost of calcium chloride, if applied in the converter or open hearth, is about 9*d*. per ton of steel, and this expenditure is said to effect an actual saving of about 4*s*. per ton of ingots by the reduced consumption in ore and scrap.

"The only special plant required for Saniter's process is a reverberatory furnace for drying the calcium chloride, some apparatus for pulverizing the same and mixing it with lime, and a tipping ladle. The latter is dispensed with if desulphurization is effected in the converter or the open hearth

"There is at present an almost unlimited supply of calcium chloride, it being a bye-product resulting from the manufacture of soda and bleaching powder. Its present value is about 35*s*. per ton. Not more than ten per cent. of the total quantity produced is utilised, and a new use will be very acceptable to the makers. There is of course no difficulty in obtaining plentiful supplies of limestone and lime."

Used in the basic converter also.

The process is applied not only to the treating of iron as it comes from the blast furnace, but also for its conversion into basic steel; and it is claimed by Mr. Saniter that while a basic Bessemer blow alone will get rid of about 45 per cent. of the sulphur, his dual process (first in the ladle and afterwards in the converter) will get rid of 78 per cent. The steel made by his process, Mr. Saniter claims, has been tested in Sheffield for the various purposes for which Swedish bar is used in making the highest class cutlery and tool steels with marked success. "It has also been found nearly equal to the best charcoal iron for conductivity purposes. It welds splendidly. A piece which had been welded was turned and pulled in the testing machine; it broke clear of the weld, the line of which it was impossible to detect."

Quality of the steel product.

Testimony of Mr. Snelus to the value of Saniter's process.

But perhaps the most valuable testimony to the worth of this process is one furnished by Mr. George J. Snelus, vice-president of the Iron and Steel Institute, whose authority as a scientific and practical metallurgist is cheerfully recognized throughout Europe and America. The following extract is taken from Mr. Snelus' report upon the Saniter process, which was read at the last meeting of the Institute:

His report on experiments.

"I spent two days, February 21 and 22, in personally examining the working of this process at the works of the Wigan Coal and Iron Company. Every opportunity was afforded me for investigating the process from beginning to end. All samples were taken and carefully labelled by myself, and these were analysed with extreme care in my own laboratory. I had some ingots from the Siemens cast c.1134 heated on the second day and rolled into two-inch billets. These were afterwards rolled into $\frac{5}{8}$ round bars, and tested for tensile strain in my presence. The ingots were twelve inches square, weighing 16 cwt. They were heated (from cold) in 1 hour 20 minutes, and rolled off in twelve passes in the roughing rolls to nine passes in the finishing rolls. I was remarkably struck by the fine quality of the steel. I could not detect the slightest flaw or sign of red-shortness in any of the ingots or in the finished billets, although I examined them minutely. In fact I never saw any steel roll cleaner or better than this did, and the practical tests fully corroborate the analytical results which follow, and show clearly that this process is most effectual in desulphurizing the commonest kind of pig iron to such an extent that the highest class of steel can be made from it. The materials employed are not costly, and there is no difficulty in carrying out the process and in producing uniformly good results.

"The process is adapted either for purifying fluid pig iron direct from the blast furnace, by running the fluid metal into a ladle having a layer of the purifying materials on the bottom, and afterwards running the metal into pigs or plate metal for subsequent use in the puddling furnace, etc.; or the crude sulphury pig is treated in the basic Siemens furnace or Bessemer converter with the patented mixture, as in the casts c. 1134 and c. 1135. Calcium chloride is the purifying material in admixture with lime. This at present costs 35s. per ton packed in own drums f. o. t. St. Helens or Widnes. It is made by the United Alkali Company from residues of the Weldon process, and containing 70 per cent. absolute calcium chloride, 1 to 2 per cent. impurities, and balance water. It is dried in rough iron dishes in a reverberatory furnace before use. In purifying the metal in the ladle, fluor spar is sometimes mixed with the calcium chloride to retard the process, and some limestone is used to save lime and produce a boil in the ladle. Fluor spar can also be used with the other ingredients, lime, limestone and purple ore in the ladle, but the mixture is not quite so efficient as when calcium chloride is used."

Full details of his experiments are given by Mr Snelus, both in desulphurizing in the ladle and converting into steel, together with analyses of the metal and slag at the various stages of steel making, and also the mechanical test of the steel, and the result of his observations is summed up in these words: "That this is a thoroughly practical, reliable and inexpensive process for desulphurization, and that by it, using the basic process, white iron made entirely from cinder can be converted into excellent steel without undue waste or loss of time."

The result.

In the discussion by members of the Institute which followed the papers, Mr. Snelus stated that he had an opportunity of seeing the process at work on a practical scale and that it was not now merely an experiment. He confessed that he had gone to the place with some fear and trembling; he thought it was in an experimental stage; but when he went there he found that it was in full working order, applied constantly to a blast furnace of ordinary capacity, running in the ordinary way and the whole thing going on as a large manufacturing operation. It was simply an examination of a process going on in ordinary working—a thing carried on daily by ordinary workmen without any instructions, but of course the men must be skilled and possess a full knowledge of the process and how to adapt it. Mr. Snelus said he had often been condemned by his friends for having ruined his own district, in which is hematite ore high in sulphur, by doing all that he could for dephosphorization; but he hoped that he should atone somewhat for that by the aid which he would give to desulphurization, because it would place in the hands of hematite makers a means of producing the very highest class of steel. Therefore he thought that the process would undoubtedly be a benefit to those districts having the class of ore in which sulphur had been a trouble as well as phosphorus.

The process is by the experimental stage, and in full working order.

The process a boon to British hematite ores.

Of course there was not entire agreement among members of the Institute on the merits of the Saniter process, and doubts were expressed by one or two members as to whether it could be depended upon for uniformity of results. Sir Lowthian Bell was characteristically cautious; that is a constitutional quality with him, and he is to be respected for it. But Sir Lowthian discussed the subject mostly from the point of view of a theorist, for he had not had an opportunity of examining the process in practice; and it is to be stated that the German objectors have also in the main spoken and written from the same point of view. Such testimony cannot therefore have the same weight or value as the testimony of men like Mr. Snelus and Mr. Stead, who have made careful study of the process after witnessing its operation.[17] Practical demonstration, in which there is not a possibility of deception, will be accepted in preference to the most ingenious speculation or theory.

Differences of opinion.

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[17] See Report of the Proceedings of the Iron and Steel Institute in Iron, May 26, 1893. At a meeting of the Cleveland Institution of Engineers held December 19, 1892, Mr. Saniter read a paper descriptive of his process in which he said:

"The application of the process to the manufacture of basic pig iron presents in the first instance the possibility of dispensing with the use of expensive manganiferous ores, and the further possibility of removing the difficulty hitherto experienced in using direct metal for steel making, owing in the one case to high silicon and conversely when the silicon is low to high sulphur. This may be simply done by using the dry mixture for the removal of sulphur only, and should the silicon be high by adding a bucket of water to the mixture a short time before tapping the furnace." Commenting on this feature of Mr. Saniter's paper at the meeting, Mr. Stead said there seemed to be at the present time a rage for studying how to get rid of sulphur. It is not so long ago, he said, that a beautiful process was perfected in Germany, but it required a large amount of manganese, which is expensive. At Wigan he had witnessed successful experiments on Mr. Saniter's process with iron containing only 0.4 per cent. of manganese, and though the sulphur was 0.4 per cent. it went out almost magically a few minutes after the chloride of calcium was added. They did not understand exactly what action took place, but the fact remained that the sulphur was eliminated, and in the course of time they would no doubt understand the action itself.

LESSONS FOR ONTARIO.

Progress of improvement in methods of treating ores and metallic iron.

The long story of invention is not closed, and in so far as the art of iron making is concerned it is not likely to close while impurities in ores and fuels continue to baffle the ingenuity of man. But the iron masters are in the line of improvement, and aided by science they are making sure headway in the face of many difficulties. The iron ores of Ontario are no worse than ores elsewhere; indeed it is almost certain that they are freer from at least one objectionable element, phosphorus, than those of other countries in which supplies are mostly found in the more recent rock formations. Better ways of treating ores in preparation for the blast furnace, and better ways of improving and refining iron and converting it into steel, as well as of strengthening it in combination with other metals, are being found out by skilled men in the laboratory, the furnace and the workshop; and every advance so made is a gain in which the whole world may share. There is not a process in the preparation and smelting of ores, not an improvement in the blast furnace, not a method of refining or working the metal, not an economy in any operation from opening the mine to the last touch of finish in the workshop, but is as free and open to us in Ontario as it is to the people of any country or state in Europe or America. Why then should not effort be directed to utilize one of the most valuable of all the raw resources of our country, converting it into wealth by the wisely-controlled agencies of capital and labor, and making it an instrument for the production of greater wealth by ways and means almost without limit and number? A talent kept buried in the earth will be no more than a talent a hundred years hence, while if rightly utilized it may reproduce itself a thousand fold in a hundred years.

The buried talent.

V.

FACTS AND OPINIONS ON THE IRON INDUSTRY.

The narrative of the failures and successes of iron making in our country, of the means which have been adopted by Governments to aid and encourage the industry, of the iron ore resources of our Province and of improved methods for treating ores in the process of extracting the metallic iron, may now be appropriately followed with information and opinions gathered in a wider field, but having direct reference to the possibilities of establishing works for the production and manufacture of iron in Ontario.

VARIOUS ASPECTS OF THE INDUSTRY PRESENTED.

In the statements which follow, Dr. A. P. Coleman, Professor of Metallurgy and Assaying at the School of Practical Science, treats of the development of our mineral resources in a general way; Samuel D. Mills gives the benefit of his experience with charcoal furnaces in Michigan and Texas; Mr. Ritchie outlines a scheme for utilizing iron ores along the line of the Central Ontario Railway in connection with nickel ores of the Sudbury district; and Messrs. Pusey, Ledyard and Conmee express opinions on a variety of practical features relating to the industry.

PROFESSOR COLEMAN'S STATEMENT.

Coleman.

Agricultural and mineral wealth of the country.

"From a geological point of view the Province consists of a comparatively small southern portion formed of paleozoic rocks with no important deposits of minerals, but covered by as productive soil as any in America, and of an immense northern and northwestern area of Laurentian and Huronian rock, of little use for agriculture, but rich in mineral resources. The fertile southern portion was naturally settled first by a thrifty, prosperous agricultural population, little inclined to unusual speculations of any kind and specially ignorant of mines and minerals. Losses in the Madoc gold mining excitement confirmed them in the belief that mines, especially in Ontario, were very dangerous investments.

"As an agricultural country Ontario has practically reached its limit. If the Province is to advance in the future as in the past, or if it is not to retrograde even, the great northwest must be turned to advantage. Its stores of timber have hitherto been a source of revenue, but fires and the work of the lumberman are steadily diminishing them. The only hope for rapid advance in the future lies in the development of the mineral resources, especially of the Huronian tracts, which as far as explored have proved rich in ores. Iron ores of unsurpassed quality and in large amounts are found in the Province; copper ores occur in very large quantities; and the world's largest known source of nickel belongs to the Province, not to mention ores of silver and gold; so that Ontario may justly be described as one of the richest countries in the world in mineral resources.

"Notwithstanding this, Ontario has been disappointingly slow in developing its mines, and what has been done has been the work not of Ontario men, but of Americans or Europeans, and has frequently been carried on in ways unsuited to our conditions. Every new mining region has its special conditions and difficulties, and the best methods of meeting them can be determined often only by costly experiments on a commercial scale. No mining region can reach the highest prosperity merely by shipping its ores to other countries, Coleman.

Advantages of smelting works.

and it is safe to say that until Ontario ceases to sell its ores and low grade mattes and begins to smelt and refine its own iron, steel, nickel and copper, no great advance is likely to be made. The establishment of smelting works of any kind on the right scale and wisely managed will give a market for many ores of too low grade for export, and will serve as a nucleus for a dozen other industries of great importance.

Skilled labor and good markets.

"The starting of the manufacture of good quality steel, for instance, would probably be followed by the refining of at least part of our own nickel, to be used in making nickel steel, and that by the refining of the associated copper. I need not say that this would imply a demand for skilled and highly paid labor, would lead to the building up of great manufacturing centers through the cheapness of the main raw materials, and would afford the best possible markets for our farmers.

Capital and experience required,

"But the founding of such metallurgical establishments on the proper scale demands a large capital and great experience; and at the outset there would probably be little or no returns until the experimental stage was over. In many other countries this costly and discouraging initiatory period has been tided over by governmental aid until things had reached a self-supporting basis.

"In a purely agricultural country like Ontario encouragement is particularly needed, since our people have not yet developed the skill and experience required for success in this direction; and the foreigners who might be expected to undertake the work are already interested in the success of rival establishments in the United States, England or other countries.

which ought to be encouraged by Government aid.

"Under all the circumstances it appears that our Government would be justified in aiding in whatever way seems wisest the establishment of smelting works in the Province, such aid of course to cease when no longer needed. Such a course has been adopted with advantage by many other countries. Norway and Saxony have even owned and worked important mines and smelting establishments with great benefit to the State.

A turning point in our history.

"In my opinion Ontario has reached an important turning point in its history. If no new departure is made our Province must stand still or even retrograde, while a wise utilization of our mineral resources will give the starting point for a growth of population and wealth which will keep Ontario in the front rank as compared with the rest of the world.

Financial aspect of the question.

"To the Government of Ontario this question has a very direct importance from the financial side. The revenues now derived from the sale of timber limits will not last always; but if mining and smelting receive the proper attention this loss of revenue may be much more than made up in royalties."

SAMUEL D. MILLS' STATEMENT.

Mills.

"I am an old countryman by birth. I studied at the Royal School of Science, Dublin, intending to follow mining engineering, but family circumstances led to my abandoning that idea, and for seven years I did nothing at it. I formerly resided in Kingston, Ontario, for nearly four years. I have had no experience in iron-making in Canada. During the time I lived in Nova Scotia, about three years, I was a partner in a private company engaged in mining barytes, but owing to some changes in the market we could not work at a profit, and, there being indications of lead, copper and silver on the property, I was engaged in attempting to develop these. I lived in Nova Scotia from 1874 to 1877, and took advantage of opportunities I possessed of visiting and studying the working of the furnaces at Londonderry. Mr. Brown, the general superintendent, being a friend of mine, proposed that I should take the position of chemist and assistant superintendent, but a change in the management prevented my doing so. When I went to Kingston I opened a mineralogical and mining office, and remained there for three years trying to work up some interest in connection with the mines there. I examined many of the mines in that district at that time. I examined the iron mines north of Kingston, in Frontenac principally, and

Mills.

also in Lanark and other parts of that country. I was partly exploring for my own purposes and partly examining for others. Folger Bros. got me to go up and make a report on the Mississippi iron property, and I examined some mines farther north for my own satisfaction; these mines were being worked then. I wrote a report for Messrs. Folger which was published in the Kingston Whig at the time, somewhere about 1879 or 1880.

Blast furnace experience in Michigan.

"In 1881, finding that business continued dull, and it was impossible to get up any interest in mining at Kingston, I abandoned the attempt. I got an offer to go to Michigan to take charge of the new chemical works and blast furnace at Newberry, in the northern peninsula, about 75 miles from the straits of Mackinaw. I remained there for nine months, when I went to St. Ignace and took charge of the Martel furnace and chemical works, where I remained for about eight years. The St. Ignace furnace was built before I went there, and had been running about eighteen months. The supply of ore for this furnace came from many different mines in Michigan, mostly from the neighborhood of Ishpeming. Some of it came by rail a distance of about 165 miles. We used a mixture of ores. During the last fifteen months I was there we experimented with thirteen different kinds of ore, showing the range of ore obtainable there. We used brown hematite, a certain proportion of red hematite, hard specular and magnetic ore. When I speak of red hematite I mean both the soft, earthy variety and the hard specular ore. The regular practice in that furnace was to use a mixture of five different kinds of ore in the same charge, mixed in given proportions. In the manufacture of car-wheel iron the obtaining of a proper quality of chill is a matter of very great nicety, and one requiring very close attention, and the mixture of the ores was made with the view of accomplishing that object. We experimented carefully so as to find out the proper mixture, and the proportion of the various ores was regulated accordingly. We never tried to produce a suitable quality of iron from magnetic ore alone, as we had no occasion to do so. It would not have been economical, because the magnetic ores were the highest priced ores we used. We used only a small proportion of them, what we could not do without. The bulk of the ores were hematite, chiefly red.

The St. Ignace furnace.

Quality and cost of ore smelted.

"During a run of 167 days from April to October, we experimented on the following varieties of ore:—Imperial, a brown hematite; Webster, the same; Cleveland Lake, a soft red hematite; Old Mine, a similar quality of ore; Cleveland Scotch, Dexter, East New York No. 2, and Lake Superior No. 1, all hard red hematites; Michigamme and Comrade, magnetic ores. The names given are those of the mines. Some of the hard red hematite ore was specular. The following are the quantities we used during that campaign:—Imperial, 3,405 tons; Webster, 115 tons; Cleveland Lake, 3,722 tons; Old Mine, 2,369 tons; Cleveland Scotch, 3,668 tons; East New York No. 2, 622 tons; Lake Superior No. 1, 954 tons; Michigamme, 1,016 tons; Comrade, 91 tons, and Chelsea, 99 tons. The average yield of iron for the 167 days was 57.8 per cent. The mixtures did not remain the same for the whole time; for a week or so perhaps we ran upon one mixture and then changed over and tried another. Of some of the ores, as you will notice, only very small quantities were used. I cannot give the percentage of iron in all of these ores; but here are averages of a few of them:—Imperial, 57.8 per cent of iron; Lake Superior No. 1, 65.2 per cent.; Cleveland Lake, 61.5 per cent.; Cleveland Scotch, 62.6 per cent.; Michigamme, 65.5 per cent. The total make of iron during the run was 9,361 tons. I have not got the exact figures as to the cost per ton of the iron ore laid down at the furnace, but the quantity of ore required to make a ton of iron cost us $6.55, the ore yielding an average of 57.8 per cent. of iron. When I speak of the ton of ore I mean the net or short ton of 2,000 lb., in which way be bought all our ore, but the iron was sold by the long ton of 2,260 lb. I give the product in long tons, but the ore in short tons. In Texas we allow 2,268 lb. to the long ton.

Mills.

"We manufactured our own supply of charcoal to a large extent. We made it at two different sets of kilns, and also bought some from outside parties. One set of kilns was twelve miles from the furnace, and the other was between twenty four and twenty-five miles up the railway. We used beech, maple, birch and a little elm in making charcoal, as little elm as possible. It was all hardwood except a little soft maple. The timber was good and heavy. We could cut from 40 to 45 cords of wood from an acre. We cut up the whole tree, everything down to three inches thick. A cord of wood would make about 45 bushels of charcoal in the kilns. We did not make it in any other way; we did not use any pit coal. I cannot tell you what the charcoal weighed per bushel; we called 20 lb. a bushel and settled for it and paid our colliers, etc., on this basis. At one time we kept accurate account of the coaling and handling of 2,000 cords of wood, and the resulting charcoal cost us 4½ cents per bushel f. o. b. cars at the kilns. The freight to the furnace was three-quarters of a cent per bushel. During the campaign I mentioned we used 870,000 bushels of charcoal. The cost of the coal per ton of pig iron was $6.89. At the second set of kilns, which was not so well managed, the coal cost us more, and the coal we bought from outside parties cost us very much more than it ought to have done.

Production of charcoal fuel.

Flux.

"With regard to flux, we were most fortunately situated. During the last run I decided to extend the stock-house, which was not large enough to carry a proper supply of ore for the winter. On commencing our excavations I found that the upper end of the stock-house was built on limestone, and we excavated the limestone for flux and extended the stock-house at the same time. Before this we had quarried the stone about a quarter of a mile from the furnace. The quantity of limestone we used for flux varied according to the nature of the ore. We used a very small proportion, as our ores were low in silica and were to some extent self fluxing. The Webster, Imperial and some of the other ores carried a good deal of lime, so that our proportion of limestone ranged from 40 to 70 lb. per charge, averaging perhaps 60 lb. An average charge consisted of 1,800 lb. of ore; with that we would use 50 or 60 lb. of limestone, which is a very low proportion. We did not put an estimate on the cost of the limestone, as under the circumstances it really cost us nothing; we were obliged to excavate it in order to extend our stock-house.

Cost of labor.

"As to the furnace itself, a correct description of it, giving the dimensions, etc., was published in the Charcoal Iron-Workers' Journal. The machinery, blowers, etc., were also described in that article. We had 26 men employed about the furnace; then there were the engineers and others; in all there must have been 38 men. The cost of labor per ton of iron was $1.42, which includes superintendence, fuel for switch locomotive and blacksmith's wages.

Total cost of production.

"The facts which I have given regarding the campaign referred to will apply to the general run of our work. We have done better, and we have done worse. At the prices which we were paying for the ore, labor, etc., the total cost of production of iron per ton was $15.70. According to the books in the office the cost was $15.94; but there were some charges which ought not properly to have been entered against it. The pig iron was used exclusively in the manufacture of car wheels, and very largely by our own people. The furnace was built for the express purpose of supplying the Erie Car Works, the property of Davenport, Fairbairn & Co., at Erie, Pennsylvania.

Experience in Texas.

"I was nine years in Michigan altogether, leaving there early last year and going to Texas. I did not build the furnace at Texas; it had run for about six weeks and then shut down before I took charge. It is supposed to have a capacity of 50 tons, and I hope we shall make it a 50-ton furnace, but owing to defects in construction it did not run over 40 to 45 tons. It is larger than the Martel furnace; it is 60 feet high by 11 feet bosh, and 6 feet

Mills.

6 inches crucible. There are six tuyeres; the Martel furnace had five. We use the warm blast in Texas, from 500° to 900°. At the Martel furnace we used from 1,100° up as high as 1,800°; I have run as high as 1,800°. We use the gas from the furnace in heating our boilers and heating stoves. The furnace is located at New Birmingham, Cherokee county, Texas.

Bog ore.

"The ore used at the furnace occurs in what is known as a blanket deposit. It is found on the tops of hills, at an elevation of about 700 feet above the Gulf of Mexico, throughout the counties of Angelina, Rusk, Cherokee, Smith, Henderson, Anderson and several others. The level is so invariable that you can almost tell the elevation at which you are above the gulf by finding this ore. It is a brown hematite, somewhat similar to the bog ores of Quebec. It is a bog ore formation and is found near the surface, the earth being removed by means of ploughs and scrapers. The ore is then broken up with bars and picks, very little powder being used, and after stripping a bank of ore the earth from the next strip is thrown into the excavated place, so minimizing the cost of excavation. The beds range in thickness from 18 inches to 3 feet 6 inches. It is covered with sand, and generally underlaid by sand also; it is not found in vegetable mould. The thickness of the overlying sand varies from nothing to 12 feet, but we do not touch the deeper portions. If the bed is covered with more than six feet of sand we leave it. The ore analyzes 45 per cent. iron, and will yield in the furnace somewhere about the same. There has been an amount of irregularity in the output of the furnace that shows an irregularity in the ore itself. It has appeared to run from 45 to nearly 50 per cent. in the furnace. It must be more than that in the ore, but pig iron is not all iron by a good deal. The softer grades particularly run down as low as 96½ per cent. of iron, the balance being silica and carbon. There is a large amount of graphitic carbon, as much as two or three per cent., in the softer irons. There is some sulphur and phosphorus in the ore. I have not the analysis here with me, but it sometimes runs as high as 0.2 per cent. of phosphorus. There is a little sulphur; some analyses I made myself ran from a trace to .06; it varied considerably. We lay down the ore in the stock-house at a cost of 65 cents a ton. Our labor is not so very cheap; it costs us from $1 25 to $1.50 per day. It is negro labor chiefly, and we find it efficient. With a gang of forty or fifty negroes we have two to four white men as drillers; and in case we use a little powder we employ the white men to drill. We pay our foreman miner $2.50 per day.

Charcoal.

"Our company makes its own charcoal. Up to the present time we have been making it in pits exclusively; but the intention of the company is to raise some more capital and go into larger development, probably building another furnace, and more kilns for making the charcoal. There are two kilns already built, which I put up last year. The supply of wood for charcoal varies in distance from the furnace. Our kilns will be located at the furnace, but that will have nothing to do with the point of supply of the wood, which will be brought to the kilns by rail. Our charcoal has been costing us somewhere about seven cents per bushel; we expect to cut the price down considerably.

"We ran our last campaign about eight months, and then decided to shut down for alterations and repairs. There were a great many repairs found necessary, and a great many alterations were required in the stock-house and in other ways. We are subject to very heavy rains there, and the upper works of the furnace were leaking so that the rain got into the furnace. The low price of iron had a good deal to do with our shutting down; it was the principal reason. Iron went down to such a price that it would only net us $12 per ton, and it was costing us $11.75 to $11.90 to produce it.

Mills.

Iron ores of the Kingston district.

Prospecting with the diamond drill.

"Coming back to Ontario, I cannot say that I have any other knowledge of the iron deposits of this Province than I gained during my explorations in the neighborhood of Kingston. From what I then learned I formed the opinion that there were large bodies of iron ore in the Frontenac country and its vicinity. I felt certain that there was a large amount of iron there. It was of good quality, not to be surpassed anywhere. It was chiefly magnetic. There were some indications of hematite, but hematite ores are not to be discovered by the use of the dip needles; nothing but actual work will show their presence unless they crop out. The only way to find them is by using the diamond drill. I have seen indications of outcroppings. Where discoveries are made in Michigan and Wisconsin of hematite ores the diamond drill is used very largely in prospecting for them. There will always be more or less indication on the surface in the case of hematite ores from the discoloration, but I have heard of borings being made without any surface indication. Brown hematite is always found by the discoloration. It is almost always at the surface, and you will find a very frequent indication to be the deposits from the water. If you find a spring of water leaving a deposit of brown ore you may be perfectly certain that there is a body of it somewhere in the neighborhood. I certainly recommend the use of the diamond drill in prospecting for red ores, and for magnetic ores as well. In the case of magnetic ores we do a good deal with the dip needle, but as a confirmatory test I consider the diamond drill is necessary.

Treatment of magnetic ores.

"In furnace work it is found to be very desirable to use a mixture of hard and soft ores; but hard magnetic ores may be greatly improved for furnace treatment by roasting. By adopting the following plan such ores can be used for smelting without mixture: take a portion of magnetic ore and use it in its raw condition, and roast the rest of it. In New Jersey this plan is followed. The object of the roasting is to change the nature of the ore and convert it from the protoxide to the sesquioxide, thus virtually changing it into a hematite ore. The advantage of the hematite is that it is an open ore, more open than the magnetic, the consequence being that in the furnace it takes up carbon more readily and parts with its oxygen more rapidly. The reaction is much more rapid with hematite ore than with magnetic; the reason being that in the first place the latter ore is dense throughout, and in the second it has a smooth polished surface, consequently it resists the action until it goes down a certain distance in the furnace. Long before the hematite ore has reached that level in the furnace it is to a great extent reduced and thoroughly saturated with carbon. The practice of roasting magnetic ore and using ore thus treated with raw magnetic ore in the furnace is followed at Boonton in New Jersey; when I was there some years ago I found them running entirely upon that plan. The Oxford furnace, situated at a town in New Jersey whose name I do not now recall, has carried on the same practice. At Boonton they roasted the magnetic ore in heaps. They took cordwood and laid it in rows lengthwise about three fee apart, covering a width of about 30 feet; they then bridged this over with a regular layer of cordwood laid close together, and on this the ore was piled and ranked back with the sides sloping at an angle of 45 degrees. In firing, in addition to the wood they occasionally put a little coke dust along with the ore, but the ore carried a good deal of sulphur, and the sulphur assisted in the roasting. The presence of sulphur in the ore was certainly part of the reason why it was roasted, but they would have had to follow this plan in any case because they could not run on magnetic ore alone. The furnace would run irregularly and give no end of trouble; besides, a proper quality of iron could not be made in this way. By roasting part of the ore they were able to make the quality of iron they required. They used coke for smelting. They made ordinary merchant bar; they had also a rolling mill and puddling furnace, and I think put the whole product of the furnace into merchant bar.

Mills.

Charcoal and coke irons are needed in Ontario.

"From what I know of this country I would advise the making of both charcoal and coke iron. You have an ample supply of charcoal available in the country. I think you could manufacture charcoal iron to greater advantage than coke here, because in the latter case you would have to import your fuel. The trouble is there is often difficulty with stove manufacturers and others in using charcoal iron, owing to its tendency to chill. They prefer coke iron for ordinary purposes, for the manufacture of water pipe and things of that kind. At the same time for heavy castings there is no objection whatever to the use of charcoal iron; on the contrary, it is an advantage because it is a better iron. It makes a stronger and better finished plate than coke iron, but when you come to make thin castings like stove plate there is a little difficulty; there is some danger of getting a chilled casting, and there is a difference in the grinding, etc. Mixing a small quantity of charcoal iron with coke iron gives a tougher plate, but to make it exclusively of charcoal iron does not answer so well. If you want to make good malleable iron castings however you must have charcoal iron.

Cost of ore in Ontario as compared with Michigan.

"I think charcoal iron can be made more cheaply here than in Michigan, because you can get your ore cheaper here. I am convinced of that. You can get it in sufficient quantity, and I believe it will cost you a dollar a ton less for ore than in Michigan. I figured on getting ore here at such a price when looking into the question here a few years ago, and my calculations were based on information I received from Mr. T. D. Ledyard, from my own knowledge of the cost of ore at the mines north of Kingston, and from information I got from other parties with whom I went thoroughly into the matter. I came to the conclusion that the ore for the manufacture of iron here would not cost us more than about $4 per ton, which is over $2 a ton better than in Michigan. When I say $4 a ton I mean $4 for the ore required to make a ton of pig iron.

Cost of roasting ore.

"The roasting of the ore at Boonton costs 25 cents per ton. It may cost a little more, but I understand it has been done for that in other places. The cost depends entirely upon the facilities you have for obtaining roasting material; where you have charcoal braize collecting about the furnace it is a very easy method of getting rid of it. On roasting a large quantity of ore in Texas we found the process cost us 25 cents per ton, and it improved the ore some. We used charcoal braize, and had to haul it a mile and a quarter. We found it paid to roast the ore at the mines better than to haul the ore to the furnace and roast it there, as we had no facilities for roasting it at the furnace. When the miners were mining the ore they would load it right into the carts and the carts delivered it on top of the kiln where it was roasted, thus saving one handling. When the waggons came from the mine with the ore they took charcoal braize back, and so this plan we found to be the most economical.

Competition of charcoal and coke irons.

"The fact must be taken into consideration that charcoal iron made here would come directly into competition with coke iron. Users of iron would prefer it if they could get it at the same price, and possibly they might pay a little more for it for some other purposes, but when I was investigating some years ago I found that the malleable iron makers of Canada were using coke iron, although supposed to be using charcoal iron. Some of their employés admitted to me the fact that they could not make malleable castings equal to the United States castings for the simple reason that charcoal iron was used in the United States and coke iron here. I consider that charcoal iron could be made here more cheaply than at the Martel furnace, or in Wisconsin, but supplies of coke iron from Great Britain would doubtless come into competition with our charcoal iron.

Cost of producing coke iron.

"With regard to the cost of producing coke iron here, I made some calculations three years ago, which might perhaps have to be modified a little now; but as near as my recollection serves me, the estimate I arrived at

Mills.

Nova Scotia and Pittsburgh cokes.

was $14.50 per ton, assuming we could get coke in duty free. Coke would cost us more here than at any point in the United States equally distant from the source of production, for the reason that we would not have return cargoes, unless we could get out our iron ore so cheaply as to be able to compete with the American ore and carry the duty as well. I am not favorably impressed with Nova Scotia coke. From what I have heard of it I believe it contains a large proportion of ash, running all the way from 8 to 20 per cent. I do not think it contains much sulphur. Pittsburgh coke contains from about 5 to 8 per cent. The worst Pittsburgh coke is about on a par with the best Nova Scotia, so far as I can learn. I do not think the Nova Scotia coke contains a higher percentage of sulphur than the Pittsburgh coke; I do not fancy that it does. But the cost of freight on Nova Scotia coke would be enormous. The magnetic iron mines north of Kingston are very much nearer to Pittsburgh than the lake Superior mines. The question whether you could send return cargoes ot ore would depend largely upon the price which the mine owners would set upon the ore. If they were satisfied with a reasonable profit I see no reason why a trade could not be done. If they were exorbitant in their demands, it could not be done. I assume that a much larger quantity of iron ore would be raised if we could smelt it. If a start were once made I believe the business would develop, and that a much larger amount of ore would be mined than we could use ourselves. In that way we might be able to afford return cargoes to Pittsburgh and establish a regular trade back and forth. If once a mine was opened and thoroughly worked, it would pay to ship ore to the States in face of the duty.

Protection against British iron makers.

"In the attempt to establish an iron industry here with a protection of $4 a ton on pig iron and a bonus of $2 per ton, the competition of British iron makers would have to be met. You would probably make at first a quality of iron only equal to a low grade of English iron. We have not the selection of ores they have; we may have better ore, but we have first of all to learn how to use our ores in order to produce the best quality of iron. It would not be safe to go upon any other ground than to count upon making at first an iron equal to the lowest grade of English iron, which at present commands a price of about $16.25 per ton here, duty paid. The cost at which I estimated we could make iron here was $14.50 per ton, which leaves us only $1.75 and the $2 a ton bonus, equal to $3 75 a ton altogether. Against this we must set the probability of the English furnace-masters putting the price of their iron down to somewhere about $13 per ton, which they can do. They would, I believe, make a push to meet the competition of iron made here, and they would even sell their iron at a loss at the start with a view of crushing the industry out. In order to make the undertaking a success we ought to have about $2 a ton more duty, and the duty on scrap iron ought to be made the same as upon pig iron. The present duty on scrap iron is only $2 per ton.

The trade in steel rails.

Low duty on scrap iron.

"Another point is this: if we want to establish a large iron industry, something like the Pittsburgh industry, as we certainly can do if we set the right way about it, we must get a chance to make steel rails, which are now admitted free of duty. I would advise putting a duty of $6 a ton upon iron. I think it is $12 a ton in the States. But the removing of steel rails from the free list and the placing of the same duty on scrap iron as on pig are the most important things. It might be we could get along if we were saved from competition with scrap, which coming in at a duty of $2 a ton supplies a large proportion of the demand. I was talking to Mr. James Worthington of the Bolt and Nut Works a few days ago, and he said there was a large amount of scrap coming into the country. I would propose to put the duty on scrap iron up to the duty on pig, or near that figure. I think we ought certainly to manufacture all our own iron. If rolling mills for the manufacture of round and square iron and iron of various kinds, as well as steel rails, were established, one would help another, provided the duties were equalized; if for instance the duty on merchant iron were not so low as to partly counteract the duty on pig. Of course if the English manufacturers found themselves unable to send their pig iron they would send their bar if they could get it in cheaper than pig, and the result would be to hamper us again. It would be necessary to make sure that we had sufficient protection against that as well.

Mills.

"There is another serious difficulty in connection with the proposal to establish an iron industry here, and I do not know how it is to be met. It is the feeling that exists amongst capitalists, both here and on the other side, that even if a sufficient duty were placed upon iron it would be liable at any time upon a change of Government to be removed or reduced, in accordance with the politics of the incoming party, and that capital invested in the iron industry would consequently not be safe. The question arises, What guarantee can be given to capital that such changes will not take place? Of course if the industry had once taken firm root in the country, so that a large proportion of the population were directly or indirectly interested in the maintenance of the works, the question would settle itself, but until a sufficient proportion of the people to make themselves felt in politics become interested in the maintenance of the industry, this difficulty will stand in the way. I have this very statement made to me by capitalists in the United States when speaking to them on the subject, not only in connection with iron, but as regards timber limits as well. Some years ago I was trying to sell some timber limits for a friend on the other side, amongst others to some Bay City and Saginaw men, but they would not touch them. They said 'We do not know the minute your Government will put an export duty on timber.' In the United States the Democratic party certainly favors a revenue tariff, but the iron industry is of such enormous magnitude that I believe if the Democratic party were to take the ground squarely and say 'We are going to admit iron free,' it would simply put them on the shelf forever. They would have no chance at all. I am aware that at the last election the Democratic party adopted the plank of tariff reform, not specifying particularly a reduction of the iron duties, though these duties were widely discussed, and it was pointed out by Wells and others that they were a heavy tax on the producing classes of the United States. There is no doubt that the iron duties in the United States are too high, unnecessarily high. I think the position taken by the Democratic party affected the investment of capital to some extent, but the fact is I have been too much engaged in actual business to pay very much attention to politics. It is perhaps a curious conclusion to come to, but my impression is that the iron business in the United States would probably be in a more healthy state were it not for the high duties. So far as this country is concerned, the great bug bear, the sticking-point, seems to be the fear entertained by capitalists that a protective tariff might not prove a permanent one.

The uncertainty of protective tariffs.

"There was an observation made to me the other day to the effect that the capitalists who had money invested in the industries of this country and who were developing its resources were chiefly Conservative in their politics, and that on the other hand the capitalists of the Liberal party had carefully abstained from putting their money into manufactures of any kind, but had invested it in mortgage and loan companies, in real estate, in shares of gas companies and in railway stocks and things of that kind. An observation of that kind shows what the impression is. I am not in a position to judge whether or not the statement is true, but the gentleman who spoke to me had every opportunity of being well posted."

SAMUEL J. RITCHIE'S STATEMENT.

Ritchie.

Central Ontario Railway built to develop iron ore properties in Hastings.

Ore of the Coe Hill mine rich in iron, but high in sulphur.

"I am interested in iron lands along the line of the Central Ontario Railway and in all the copper and nickel lands belonging to the Canadian Copper Company, as well as in the lands belonging to the Anglo-American Iron Company and those formerly belonging to the Vermilion Company. I think there are a little over 70,000 acres of iron lands held by our Company in Hastings county; I am not sure of the exact acreage. This does not include the Coe Hill mine, in which I am not interested. The Central Ontario Railway was built for the purpose of developing this property. The first thing we did was to make a contract with Mr. Coe when we purchased the lands now represented by the Coe Hill Mining Company, 14,000 or 15,000 acres additional, to build a railroad up to those lands and develop them. The railway was built from Trenton northward wholly and solely to operate and develop the iron interests there. We constructed ore docks at Weller's bay, and so far as transportation went we had all the facilities for developing and carrying the ore. We carried on operations at Coe Hill for two or three years, and got out eighty or a hundred thousand tons of ore; I do not now recollect the exact quantity. The ore went principally to Cleveland, where it was remelted by the Cleveland Rolling Company. The results were satisfactory until the ore began to develop sulphur. There was very much less sulphur in the ore at the surface than farther down, so that not much was thought about it for the first cargo or two The ore was rich in iron, carrying about 65 or 66 per cent. This mining was done in 1883 and 1884. We discontinued operations because of the sulphur, which rendered the ore unsaleable. There is a large quantity of ore lying there now. An attempt was made to roast it in the form in which it was mined, in coarse lumps, and the result was that only for half an inch from the surface was the sulphur driven off. The ore was not very dense. At that time the practice of breaking ore for the roast heaps was not adopted to any extent in the United States. There were furnaces where the ore was roasted, among others the furnace known as the Taylor & Langdon, but they were only adapted to treat the ore in a small and rather expensive way. From my explorations I am satisfied that there is any quantity of iron ore of this grade—containing more or less sulphur—in the district I am speaking of. I had Mr. Bolger make a survey for the railway, and in his report he states that for a distance of seventeen miles on a portion of the line immediately north of Coe Hill the compass was utterly useless; iron seemed to be present in mass all through the country. There is no doubt about the extent and quantity of that class of ore, such as could not be utilized then, but is now valuable when treated by the concentrating process. I did not find any red or brown hematite ore there.

Processes for cleaning and concentrating ores containing sulphur and phosphorus.

As to the concentration process, a machine has been patented by Lovett & Finney of Chicago which I have seen in operation at various places, and which I believe to be a great success. I have watched the machine in practical operation at a place in New Jersey where it is operated by the firm of Hecksher & Sons of Philadelphia. They were running it there on a very lean ore; magnetic of course, as it is no use for any other kind. It is a magnetic separator, and in my opinion is adapted to treat the Coe Hill ore. Washing the ore is an additional process after treatment in the magnetic separator. This machine combines the two processes; you can of course run it without the water, but the ore is much improved by adding the water, because it takes out nearly all the phosphorus. This machine reduces the ore to a fineness of about 10 or 15 mesh. I had a large model of it constructed and brought to Trenton, and had about half a ton of ore crushed to about 15 mesh size, and put through several hundred pounds in the presence

Ritchie.

of about a thousand people during the ten or twelve days we were there. A machine running with a 48 or 50 inch belt will run through five or six tons of hard ore an hour. It gives an ore practically free from phosphorus. Of course where sulphur is in chemical combination with the iron the machine will not take it all out, but the experiments I have made show that we can drive that sulphur off with a low degree of heat in about half an hour afterwards. The ore varies with respect to the way in which the sulphur is combined with the iron. Sometimes it is found in chemical combination and sometimes in mechanical combination; it is not a serious matter whichever way it is. At one of the mines on the Hudson river they have been able to desulphurize the ore at a cost of from 9 to 13 cents per ton after the mechanical process has been gone through with, leaving it free from these impurities at a cost of 20 cents per ton. The whole process, concentrating and desulphurizing, might cost 40 or 50, or perhaps 60 cents for a ton of concentrates. That would give an ore free from sulphur and phosphorus and containing about 68 or 70 per cent. of metallic iron, and would enable us to use the entire product of a mine instead of only half or two-thirds of it as you now do, and thus make a great saving in the cost of mining. Edison is treating ore successfully containing only 18 per cent. of metallic iron. There is also a saving in freight charges when transported; the freight rates are lower, as it does not injure a boat or a car any more than a load of wheat. Furnacemen used to say that a charge of this concentrated ore would choke a furnace, but they have got over that nonsense now. The Bethlehem Iron Company are producing the finest steel in the world, and they tell me that they can use 50, 60, or even 75 per cent of the fine ore. They make an offer to buy all they can get. I have a correspondence with them which reads as follows:

'BETHLEHEM, PA., October 17th, 1891.

'Mr. R. P. LINDERMAN, President of the Bethlehem Iron Company, South Bethlehem, Pa:

Concentrated ore smelted at South Bethlehem.

'DEAR SIR,—I am interested in a large amount of iron ore along the line of the Central Ontario Railway in the Province of Ontario. Your Company has also made quite a large investment immediately upon the line of this railway. The larger portion of the ores in which I am interested are not marketable in the form in which they are mined from the ground, owing either to the fact that they contain too much sulphur, or that they are too low in metallic iron. For these reasons the mines have not been worked for the last four years. I have thought that the new method of concentration and separation by the magnetic process would afford a solution of these difficulties, but it is urged upon me that fine concentrates cannot be successfully used in the furnace, and that there is therefore no market for this kind of ore. I would therefore be greatly obliged to you if you would give me your experience in answer to the following questions:

'1st. Have you been using, or are you now using, fine concentrated ore in your furnaces? If so, are the results obtained from it as good and favorable as those obtained from coarse or lump ore?

'2nd. What percentage of the whole charge in the furnace of this fine ore do you use, and how high a percentage do you think you can successfully use?

'3rd. Do you manufacture any pig iron from ores which contain any considerable percentage of sulphur? If not, do you purchase pig iron from parties who do make it from ores which contain sulphur? If so, who are the parties who make pig iron from sulphurous ores? How much sulphur do the ores contain as mined from the ground, and which are afterwards smelted into the pig iron purchased by you?

Ritchie.

'4th. Does the pig iron made from these sulphurous ores contain any sulphur, and can it be used in the manufacture of Bessemer steel, and is it so used by any considerable number of Bessemer steel manufacturers?

'5th. Would you be willing to purchase any large quantity of fine concentrated ore? Very truly yours,

(Signed) S. J. RITCHIE.'

'THE BETHLEHEM IRON COMPANY,
'SOUTH BETHLEHEM, PA., Oct. 17th, 1891.

'Mr. S. J. RITCHIE, Akron, Ohio:

'DEAR SIR,—Answering your letter of the 17th inst, I beg to reply to the several questions that you ask me as follows:

Percentage of concentrated ore smelted in the Bethlehem furnaces.

'1st. We have used and are using a certain percentage of fine concentrated ore in our blast furnaces; the results, so far as I am aware, are as good as those obtained from coarse or lump ore.

'2nd. The highest percentage of concentrated ore which we have so far used in our charge is about 50 per cent., but I see no reason why a higher percentage might not be successfully used. If the ore is low enough in phosphorus, so that it need not be reduced too fine to eliminate that element, I see no reason why we should not use as high as 75 per cent., or possibly more

'3rd. We do not manufacture any pig iron from ores which contain any considerable percentage of sulphur; we do however purchase pig iron from parties who do use ores which I understand contain in their natural state quite a high percentage of sulphur—the ore referred to is the Cornwall ore. I cannot say how much sulphur these ores contain as mined from the ground, but have no doubt that the parties who use this ore would willingly give you this information.

'4th. The pig iron made from Cornwall ore contains some sulphur, but not sufficient to prevent its being successfully used in the manufacture of Bessemer steel, and it is so used by the large steel rail mills in the east.

'5th. Whether we would be willing to purchase any large quantity of fine concentrated ore would depend almost entirely upon the price and quality.

'Trusting that the above will satisfactorily answer your questions, and holding myself ready to give you any further information that I can, I am, Yours truly,

'(Signed) ROBERT P. LINDERMAN, President.'

'I have also a letter from Thomas Edison on the same subject, of which the following is a copy:

'ORANGE, N. J., November 26th, 1889.

'S. J. RITCHIE, Esq, New York City.

Edison's magnetic separator.

'DEAR SIR,—Replying to your letter of 21st instant, in regard to refining ores in Canada by means of my Magnetic Ore Separator, I beg to answer your queries categorically as follows:

'1st. What would be the approximate cost per ton of the ore as mined from the ground, for crushing and separating the iron contained in it from the silica or other foreign matter, by your process? A. Actual cost, 62 cents per crude ton.

'2nd. How much iron will you be compelled to waste in the rocky matter which you separate from the iron? A. 1½ to 2 units of original ore.

'3rd. How high a grade of ore can you produce from an ore carrying, as mined, say forty per cent. of metallic iron? A. Average 65 per cent.; by refining concentrates, cost ten cents per ton, 68 per cent.

'4th. What would be the difference per ton in cost of producing an ore that would yield sixty per cent. and one yielding sixty-eight per cent.? A. Ten cents.

Ritchie.

'5th. To how low grade of ore can you use the whole product of the mine, without throwing any portion of it into the waste heap, by sorting or separating it into second-class piles? A. It will pay to use as low as 20 unit ore.

'6th. Allowing, as is usually the case in all magnetic ores, that thirty per cent. of the ore mined is thrown into the waste heap, these heaps usually carrying about forty per cent of iron, how much of the cost per ton for mining can you save by grinding up the whole amount mined and saving all the ore contained in it? A. Ordinarily, mining costs $1 per ton; if you take everything down to twenty unit, cost generally will be 50 to 60 cents.

'7th. Can you lower the phosphorus contained in magnetic ores? A. We can reduce the phosphorus 75 to 80 per cent.

'8th. Will the fine ore which is obtained by your crushing and separating process be worth as much per unit of iron when delivered at the furnaces as the lake Superior Bessemer ores containing an equally high percentage of iron? A. Yes, so the iron men say, and worth more if we go to 68 per cent.

'9th. Calling the mining of the Canadian magnetic ores one dollar per ton, the railway and lake freight one dollar and sixty cents per ton, the duty seventy-five cents per ton, seventy-five per cent. of the ores carrying fifty-five per cent., and thirty per cent. carrying forty per cent.: can you deliver this ore in Cleveland at as low a price per unit of iron as the lake Superior ores can be delivered at same place, the lake Superior ores being subject to a royalty of fifty cents per ton and the Canadian ores being free from royalty? A. About the same. Can on above assumption of costs deliver a 68 per cent. ore at Cleveland for $5 per ton, sure, against a 65 per cent. ore from lake Superior.

Cost of treating ores by magnetic concentrator.

'10th. On what terms will you erect, at your own expense, upon the line of the Central Ontario Railway at the mines belonging to the Anglo-American Iron Company in Canada, the plant for which you have now completed the plans, having a capacity for treating one thousand tons of ore per day? A. I will put up mill and refine for 70 cents per crude ton to 65 per cent., and refine concentrates at ten cents per ton, to bring it up to 68 per cent.; capacity 1,000 tons daily, no less. You may purchase mill at end of two years on twenty per cent. earnings being capitalized at par.

'11th. On what terms will you put up a similar plant having a capacity of 2,000 tons per day? A. Sixty-seven cents.

'12th. How soon can you have this plant in condition to work? A. Beginning May 1st, 1890, 90 working days.

'13th. Do you think it practicable and advisable to put up a blast furnace for smelting this ore, and a steel plant for the manufacture of steel, in Canada? If so, what measures are necessary to be adopted by the Dominion Government? A. Yes; protective tariff and a bonus for eight years.

'14th. Are you willing to become interested in the smelting and manufacturing of iron and steel in Canada? A. Yes. Very truly yours,

'(Signed) THOMAS A. EDISON.'

"I have a similar letter from the parties who treat the Hudson river ores, offering to either put up or run a plant with a daily capacity of 2,000 tons, and to reduce the sulphur down to two-tenths of one per cent. I have had further correspondence with Edison, and he offers to put in a plant capable of treating 2,000 tons per day. His process does not differ very materially from the one I have been speaking of. He uses a different kind of crusher: that is about the extent of the difference. I do not think they can use the entire charge of the furnace of this fine ore; I think they would have to use some coarse ore with it.

Ritchie.

Magnetic ore in furnace practice.

" Unquestionably a good grade of iron can be made from the magnetic ore only. The best Norway iron is made wholly from it. It is not at all necessary to mix the magnetic ore with red hematite to secure the best results.

Possibility of making coke iron in Ontario, in combination with nickel.

" I want to say that if I had not been hindered by my own associates I could have had a plant erected at Trenton, at which the ore from along the line of the Central Ontario Railway would have been treated and mixed with the nickel from Sudbury, and Canada would today be supplying the Bethlehem Company with the nickel and iron to make the plates used on the American war-ships. I have no doubt at all that iron furnaces could be successfully established in this Province. The fuel for them to use would be coke ; the distance is shorter from the place on the Rochester and Pittsburgh Railroad where coke is made than it is to Joliette, Illinois, by a hundred miles. I think this material could be taken into the United States free under the McKinley tariff, which levies the duty on the article of chief value. Suppose you make something in the way of matte and send it in the form of pig iron, I think it would go in free under the McKinley Act. Say the pig iron were worth $10 and the nickel $16, the whole would go in free, because nickel is free. This was the intention when framing that provision in the tariff law.

Demand for nickel steel.

Local market for the product.

" I think the iron industry can be most successfully established in this country in combination with the nickel industry. I do not see how it could live here alone. There would be no use in anyone trying to send iron from here to any other country, whereas nickel steel could be sent to England or the continent, or anywhere in the world. There is no question that the demand for nickel steel will be a large and permanent one. I can quote what Sir James Kitson told me the last time I saw him ; he said that every boiler in Her Majesty's war vessels would be superseded by nickel steel boilers, and that every plate upon Her Majesty's ships would be superseded by nickel steel plates, and this not only for first class, but even for second and third class vessels Sir James is ex-president of the Iron and Steel Institute. There is no doubt that nickel steel must be preferred for any purpose where great strength, elasticity and resistance are required. There is a market in the United States for this ore when treated in the way I have described, and the difference between the freight you would have to pay, for instance, from anywhere on the Central Ontario to points east of the Allegheny mountains and the freight you would have to pay from lake Superior ought to more than offset the duty. Canada ought to have a large market of her own. She has upwards of 13,000 miles of railway—a larger percentage of mileage per head than the United States—and there is no reason why she should not produce the highest grade of material for all her locomotives, cars and car-wheels which she now buys of Krupp. Krupp has got to go to Africa for his ore and ship and haul it by rail. If he gets any nickel he must go to New Caledonia or Canada for it. There is no reason why all these things should not be manufactured here. There is no such difference in labor, fuel or tariff as to prevent it. I am certainly of opinion, from observation in my own country of such towns as Pittsburgh, Chicago, Cleveland, Reading and Bethlehem, that by the establishing of various branches of the iron industry you create a local market for pig iron, and in that way you put the industry on a better basis. I do not know any country that ever got rich by selling raw material and buying manufactured, and I do not think that Canada will prove an exception. She needs to manufacture for herself ; she cannot sell grain from the farm and buy manufactured articles, paying 30 or 40 per cent. duty on them, and prosper very well.

The coke supply no hindrance.

" There is no reason in the world why the iron industry should not be established in Ontario. The Illinois manufacturers haul their coke over five hundred miles ; you do not need to haul yours over three hundred. These companies do not have any return cargoes ; the cars in which the coke is brought go back empty. No grain or anything of that kind is shipped in them. The cars are owned by the companies themselves. Train after train comes to the Illinois Steel Company with coke, and goes back empty. The copper mines at Butte, Montana, get their coke from Connellsville, and pay $18 or $19 a ton for it. I have not the figures with me which would enable me to say what amount of freight the establishment of such an industry would contribute to the railways, but I can say this that if the mineral business were taken away from the Pennsylvania system of railroads it would bankrupt it in four months, and the case is similar with all the railroads in the United States. The only wonder is how the roads here can live without such a business at all. Ritchie.

"The iron business would afford employment for all classes of labor, from the most skilled artisan to the common navvy. A great number of the iron workers in the States are paid high wages, higher than any form of labor employed in Canada. Labor in the iron and steel mills and iron furnaces of the United States is better paid than labor in the mines or on the farm—more than twice as much as farm labor. Employment of labor.

"For the manufacture of nickel steel it does not matter much whether you have protection or not. Steel rails I think now come into Canada free. You have no industry to protect, if protection pure and simple is what is aimed at. What you want to do here is to produce an article which you can not only sell at home, but export it abroad and keep your balance of trade right. If you make nickel steel you do not need to swap it for anything. You could not sell iron alone in England; carrying coals to Newcastle would be an easy task compared with that. I do not know how they could manufacture nickel steel more cheaply in England than we could here. They cannot manufacture for nothing there any more than we can here. Their coke costs as much as your coke would cost. When I was over there last, coke was higher a good deal than it was in the United States. I think that there is little doubt you could lay down coke here just as cheap as the majority of manufacturers in England get it. I do not think there is anything lacking now to enable the industry to be established, since a process has been invented to treat such ores as you have here. If you were going in, depending wholly upon the ore as it is taken from the ground, it would be another story. There is plenty of ore where there is no railway. Between the end of our railway and the Northern there are large deposits of ore containing no sulphur. But as you are able to treat the entire output of the mine by this process and get a superior class of ore, especially after roasting it, it is not so essential that a first class ore be provided by nature as it used to be. No protection needed to establish a nickel steel industry.

"I think if your moneyed men who have invested so largely in loan societies, etc., wish to protect their investments they cannot do better than set about establishing this industry. No country can ignore such a natural storehouse of wealth and expect to prosper. Compare the Southern States of today with what they were before the war, when they used to purchase everything with cotton, even the bacon they used, from the north, and see what a change has been brought about by the development of their mineral resources. Lands around Birmingham that were offered to me for fifty cents or $1 per acre could not be bought now for $5,000 or $10,000 per acre." Why capitalists are interested in establishing the industry.

CHARLES J. PUSEY'S STATEMENT.

"The facilities which the Haliburton and North Hastings district affords in the abundance and variety of ores, the accessibility of limestone for flux, and the large quantities of good hardwood for charcoal, would in my opinion enable the manufacture of pig iron to be carried on there to greater advantage than at any other point. The advantage of making charcoal iron over coke or anthracite iron is that it circulates every dollar which enters into its manufacture among the people of the country, while in the case of coke or Pusey.

Pusey.

Advantage of making charcoal iron over coke or anthracite iron.

Cost of production.

anthracite iron about one-third of the entire cost is sent out of the country for fuel. I think that is an important point. We have estimates made by Mr. Witherow of Pittsburgh, now dead, of the cost of making charcoal pig iron at Snowdon. Taking the cost of mining the ore, the cost of wood and the expense of making it into charcoal, Mr. Witherow estimated the cost of manufacturing charcoal pig iron there at about $10 per ton. On the basis of the data I gave him he said he would undertake to make it at that figure. I gave him the market value of the cordwood delivered at the railway, the cost of other supplies, the analyses of the ores and all other data he required in making his estimate. It was a little less than $10 per ton. The exact figures as given by me in the report of the Commission on the Mineral Resources of Ontario were $9.08 per ton, and I see no reason for changing them."

JAMES CONMEE'S STATEMENT.

Conmee.

Some encouragement needed for erection of furnaces.

"There does not appear to be any prospect of the ore on the Canadian side being worked to any great extent at present. If iron furnaces were built there is no doubt the ore would be worked ; in fact Mr. Caldwell offers to contract for the delivery of 25,000 or 50,000 tons or more of ore to a furnace if one were erected. I think some encouragement is needed for the erection of furnaces ; it would require capital, which the people of Algoma have not got. I am aware that there is a tariff of $4 and a bonus of $2 per net ton on pig iron. This should be a considerable inducement, but the condition which is attached to the bonus is that the iron must be produced from Canadian ores. In our part of the Province there are no Canadian mines producing ore, and so the difficulty of complying with this provision is quite serious. We cannot get a furnace built without a guarantee of ore to supply it, and we cannot induce people to mine without the guarantee of a smelter being erected. If capitalists could be got to agree together to mine ore and erect a furnace as well, it would seem to be a feasible way. I think this result might be brought about if the Government was to make a loan to a good, substantial company, which could show that it was possessed of the business experience and ability to carry on this class of work, or guarantee its bonds for a certain amount. The Government could hold the company's property as security, and in this way furnaces might be established and mines opened, and the Government would be secured for the risk. I do not think there is any necessity for the Government to assist in the working of the mines ; if they would assist in the establishment of a furnace it would create a market for the ore, and the mines would certainly be worked. I do not propose that the Government should make the company a gift of the amount, but that they should loan it ; or they might guarantee the company's bonds for twenty years, taking a first lien on the property, and if the company failed to pay the bonds the Government would have the property as an asset. I think this would enable the company to secure the necessary capital and make the undertaking a success. I do not think there would be any difficulty whatever in getting men to undertake the construction of a furnace if these inducements were offered. I feel quite sure that good men could be got to go into the business if they were enabled in some such way to secure the capital on easy terms. But if the Government would give a direct bonus it would be perhaps a greater inducement. I would consider $100,000 a good bonus, and would prefer it in a lump sum in cash ; or, say, when the works were partly completed $25,000 might be advanced, when wholly completed and put in operation another $25,000, when 100,000 tons of ore were raised and treated a third sum of $25,000, and when a similar quantity of ore was put through the remaining sum of $25,000 might be handed over, spreading the payment of the bonus over the space of two years. I think a furnace started with sufficient capital in the hands of good men would secure

Conmee.

the Canadian market. There is no duty on steel rails coming into Canada for railway purposes at the present time. There is a duty on light rails, such as are used for tramways, but none on standard railway rails. If our mines were producing sufficient ore, and we had furnaces and rolling mills in operation and were unable to get reciprocity with the United States, it might be well to put a duty on steel rails; but I am not at all in favor of protective duties. I do not think it would be wise to put on such a duty at the present time, or until our mines were further developed. I would say this, that if the United States continue to charge a duty upon rails manufactured in this country Canada should do likewise; but what would encourage the developing of our mines more than any protective duty would be free entry into the United States for our iron ores. We import steel rails from the United States in considerable quantity. As a general rule the English rails are the cheaper, but at times we can buy rails from American manufacturers to better advantage than from the English. About one-third of the rails laid down on our road were American; we could get them cheaper at the time than we could English rails. Railway companies are often in a hurry for rails, and they can get them from the American manufacturers more quickly than from the English, there is so much delay in getting rails across the Atlantic. For this reason the preference is sometimes given to the American rails, even though they cost a little more I think the C. P. R. have brought a good many of their rails from the States, but they have got their supply mostly in England. If a duty were put on rails I suppose it would have to apply to all countries. I think if our mines were developed and we had furnaces started we could compete with either England or the United States, and should not ask any duty. We have all the raw material, and we have the advantage of not requiring to pay freight; that ought to be protection enough. I think Canadian ore could be shipped to the States at present prices, if there were no prejudice against it; it would depend upon the quality of the ore offered. I do not consider the 75 cents a ton duty on ore going into the States prohibitive at all, owing to the fact that our ore occurs near the surface and can be mined very cheaply; but to handle ore and compete with the Americans it would have to be handled on the same scale that they handle it. They have the very best of railway facilities; they get their ore carried to the water's edge for less than a dollar a ton for railway transit. They have the benefit of the return cargo, but we would have that too. They have ore docks, over which they handle their ore just as grain is handled in an elevator; a vessel is loaded in two or two and a half hours, and to give vesselmen and shippers the same facilities would require the expenditure of a very large sum of money in the construction of railways, ore cars, ore docks, harbor facilities, etc., to enable the mines in Ontario to supply ore to the American market. I think the setting up of furnaces in our own country would soon be an accomplished fact if the capital were obtainable, and these together with the facilities that I speak of for shipping, etc., would no doubt lead to active mining. I believe there would be a ready market for Canadian ore in the States, because as a rule it is richer and better than the American ore. That would be a good beginning for the mining industry, but I think the most important thing of all is the establishment of smelters to supply iron for our own market. It would require double the capital to work the mines and operate the furnaces if the same company undertook the whole work, but I think if a smelting furnace could be got in operation the question of mining would settle itself. I have no doubt those who own ore would be glad of an opportunity to place it in the market. It would require still further capital to erect rolling mills for the manufacture of rails, or plates, or bar iron, but it seems to me that if a smelter were established to produce a good quality of charcoal pig iron all these other things would follow; private capital would be introduced to take

The market for steel rails.

The chance of Canadian ores in the United States market

depends on economic handling.

Interdependence of mining and smelting.

Conmee.

Advantage of Port Arthur and Fort William as seats of the industry.

hold of and establish rolling mills. I think a charcoal furnace would be the most desirable. No doubt a grant of timber by the Government for the purpose of making charcoal would be an assistance, but what is wanted is capital, something to induce capitalists to go into the business and erect furnaces and the whole plant necessary to produce pig iron. A guarantee of bonds to the extent of $200,000 would go a long way towards furnishing the means to establish the works, or a bonus of $100,000 would be of very great assistance. I think Port Arthur or Fort William are the only places where the necessary facilities can be had for the erection of the works, with convenient supplies of ore and fuel. There is a great deal of pitch pine there, as well as spruce, tamarac and birch, and I understand these are all good for making charcoal. The Port Arthur, Duluth and Western Railway goes through forest for part of the way, and there is plenty of timber within 20 or 30 or 40 miles of Port Arthur of the kinds I have mentioned. These woods are light as compared with maple or beech, but I think about fifty cords could be cut on an acre. The timber has a thrifty growth, the trees stand close together, and while each tree would not cut as much as maple or beech the yield per acre I think would be larger. I have had no experience myself which would enable me to say how many cords per acre can be cut, but I have asked the question of Captain Hooper, who was operating the Beaver mine and cleared a great deal of land for the wood, and he told me that from 45 to 50 cords per acre could be cut; a great deal of it was poplar, but the other kinds yield about the same. Then there is another point in favor of Port Arthur and Fort William in case a coke furnace was built. Vessels taking up coal or coke could carry east pig iron, iron ore or grain, and with return cargoes assured we could depend on getting the cheapest freight rates."

THOMAS D. LEDYARD'S STATEMENT.

Ledyard.

Coke fuel advised for a blast furnace located at Toronto.

"I think the proper fuel for a furnace situated in Toronto would be coke, which could be brought here just as cheaply as it can to Chicago, and perhaps a little more cheaply. There should be plenty of room in the market for the production of a furnace having an output of 100 or 150 tons a day. Our investigations led us to believe this to be the case. I have an estimate of the cost of making pig iron by Mr. Henry Kelly, who came over here independently to see my own and other properties, and who is thoroughly posted in mining. He is a member of the Society of Accountants, Philadelphia, and has been employed by some of the largest works in the United States to put their books into proper shape, and in this way he has seen the working of many furnaces. His statement is as follows, and was written after examining the properties in Belmont and Snowdon :

'Toronto, July 19th, 1892.

Estimate of cost of production.

'Dear Sir,—The following is my statement of the cost of making Bessemer pig iron in this city, based on my knowledge of the cost of manufacture in Pennsylvania, U.S.A. : Ore at $3.50=$5.78 ; coke at $4.50=$4.50 ; limestone at 75 cents=.38. Total cost of materials, $10 66 ; labor, making, $1.31 ; labor, repairs, .09 ; incidentals, .81 ; salaries, office, etc., .35. Total, $13.22. Yours truly,

Henry Kelly, Accountant.
Philadelphia, Pa'.

"Mr. Kelly was a special expert for the Cambria Iron Company of Johnstown, Pennsylvania, and other companies.

"One thing has operated against the establishment of the ironmaking industry in this Province, namely, the fact that those who wished to engage in it would have to provide all their own ore; while in the United States, for instance, they can go into the open market and buy at any time and in

Ledyard.

any quantity at the market price. There is no ore ready to be delivered in Ontario because there are no mines, and as a consequence the starting of the iron industry here would involve the risk and expense of mining the ore as well, which is a very serious consideration when you take into account the large amount of ore that should be on hand before a furnace can be started. For this reason a much larger amount of capital is required than if you were beginning a similar enterprise in the States, where you can buy ore from time to time as it is needed. For instance, take a furnace that would turn out 150 tons of pig iron per day, which would be about 45,000 tons a year To provide a year's supply of ore amounting to fully double that quantity, or say 90,000 tons and pay for it beforehand at say $3.50 per ton, would require the outlay of a very large sum of money—upwards of $300,000. If our mines were first opened and the product exported for a time to the United States, I believe the effect upon the prospect of starting the industry here would be beneficial. I know that men who are moving in the latter direction at the present time are watching with much interest the operations of the Belmont company at that mine. I think an iron blast furnace could be established here even before the mines were worked to great extent if the Government were to give a bonus. Other people besides myself who know of iron deposits say that if there was a furnace in Toronto which would give a fair price for ore there would be no lack of ore, but you would have to go farther away. These properties are about 110 miles from Toronto, but I am told that there is no question of there being a sufficient supply of ore within 200 miles of Toronto. I would not regard 200 miles a long distance to carry iron ore ; half a cent a ton per mile is the rate United States railways charge, and at this rate the cost of bringing it 200 miles would be only $1 per ton. A furnace would give a local market for ore and would use ore that could not be exported on account of not being rich enough in iron, such as hematite running from 45 to 50 per cent. I think Toronto would be as good a place for a coke furnace as any. Besides being a convenient spot at which to assemble the materials, it is a good distributing centre, which is a great advantage. Enough iron is used in Toronto and the country for which Toronto is the distributing point to support a furnace of this kind. I would certainly regard it as a very decided advantage to locate a furnace where there is a considerable local consumption of pig iron. If I were to erect a charcoal furnace I should place it near the mines. The trouble with a charcoal furnace is that it would give you only one brand of iron, and however good it might be the users of iron want a mixture. In the making of malleable castings charcoal iron is the best by all odds, but I am told that even in making carwheels they want a mixture. All the capitalists with whom I have conversed were favorably disposed towards the erection of a furnace ; they thought it was a good enterprise and ought to pay very well, but, from its being to some extent an experiment with a good many risks attached, they felt that they could not get local subscriptions for stock unless the Ontario Government also took some. It was a common opinion among our own people here that our ores were not good, but now that this American company have taken hold of the Belmont mine and are shipping the ores to Pennsylvania they may change their mind. The result of my investigations and negotiations was that we could not get any local capital interested in the scheme without an additional bonus which was looked for from the Ontario Government, and if this were given to a sufficient amount they would subscribe. I got this further promise, that if Toronto people subscribed half the required capital the other half would be furnished by American capitalists. The bonus paid by the Dominion Government upon pig iron manufactured in Canada is now $2 per ton, and will remain at that figure until 30th June, 1897. The $2 rate took effect, I think, on the 1st of July last year, and is

A hindrance to iron making in Ontario, which demands large capital to start the industry

hence a reason for Government aid.

A furnace would create a local market for ores.

Considerations which influence location.

Capitalists want more bonus.

Ledyard.

payable on the net ton of 2,000 lb. The customs tariff on pig iron is $4 per ton, so that there is a total bonus of $6 per net ton, which ought to be enough. The bonus asked from the Ontario Government is $2 per ton, to be continued for ten years."

The Iron Industries of Ontario.

It would be a mistake to say or assume that our Province is without an iron industry. A metal having such a wide range of uses as iron could hardly be excluded from the industrial arts of any civilized country. Ontario can show a list of some variety, even if the figures do not make an imposing array. The statistics of the last census are not yet available, and therefore the table which follows has been compiled from the census of 1881. It gives the number of establishments in which iron is used as the raw material of manufacture, the number of workers employed in them, the amount of wages paid in the year for labor, the value of the raw material used, and the value of the products of the works.[1]

Statistics of the census of 1881 for iron and steel works.

Industries.	Establishments.	Employés.	Wages.	Value of raw material.	Value of products.
			$	$	$
Agricultural implements.	141	3,201	1,130,475	1,613,093	3,928,411
Blacksmithing	3,586	6,026	1,409,322	1,331,730	3,906,509
Boiler works	17	260	82,492	151.700	271,833
Car and locomotive works	12	1,622	637,460	1,224,826	2,081,702
Cutlery	1	67	26,000	44,000	100,000
Edged tool works	13	337	144,030	164,280	411,550
Engine works..........	8	560	216,300	452,900	808,000
Fire-proof safe works ...	2	82	42,500	32,000	88,000
Fittings and foundry work in iron, brass, lead, etc .	75	1,084	396,021	675,458	1,388,805
Foundry and machine works	342	5,021	1,867,977	2,219,798	5,839,467
Gun making...........	24	38	16,611	8,610	34,095
Lock making	1	95	13,000	10,000	50,000
Nail and tack factories..	2	80	35,000	120,000	185.000
Rivet factories..........	3	27	10,000	15,000	72,000
Rolling mills	1	225	100,000	250,000	400,000
Saw and file cutting.....	10	165	69,100	147,330	277,400
Scale factories	1	20	7,000	18,000	35,000
Screw factories	1	66	13,700	20,809	50,960
Sewing machine factories	7	604	215,944	170.672	517,246
Spring and axle factories	4	139	46,500	118,300	178,500
Steel making	3	110	33,967	68,760	172,150
Steel barb fence factories	1	3	1,200	4,000	12,000
Tin and sheet-iron works	670	2,049	582,024	994,654	2,178,629
Wire works.............	2	19	6,900	7,500	22,000
Totals	4,927	21,900	7,103,523	9,883,420	23,009,257

Comparison with other manufactures in the Province.

Compared with all manufacturing industries of the Province for the same census year, the foregoing table shows that the iron industries were 21½ per cent. of all industrial establishments, that the number of workers to which they gave employment was 18½ per cent. of all workingmen engaged in manufactures, that the amount of wages paid to them constituted 23¼ per cent. of the total wage earnings, that the value of raw materials used was nearly 11 per cent. of the total of raw materials, and that the value of finished product was 20 per cent. of the value of all manufactures. These figures demonstrate how important a part of the industrial life of the country is taken up by the workers in iron; yet if comparison be made with some other countries it will be found to be a very moderate if not an insignificant part,—with Sweden and Belgium, for instance, or with the states of Pennsylvania, Ohio and Illinois. But it may be more instructive to borrow illustration from three or four centres of the iron industry instead of making a comparison by countries.

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[1] Bulletin No. 8 of the census of 1891, which gives numbers of establishments and of workers employed in them, shows that in some branches of the industry there has been increase and in others decrease during the last decade; but the classification is not sufficiently complete to permit of a full comparison being made, and no statistics have yet been published of wages, materials or products for the last census year.

Comparison with U. S. centres of production.

THE IRON INDUSTRY IN PENNSYLVANIA.

In the Schuylkill valley.

In October of last year I attended the meeting of the American Institute of Mining Engineers held in the city of Reading in Pennsylvania. Reading has a population of 65,000. It is situated on the Schuylkill river, off all the chief lines of traffic in the state; yet it is a hive of industry, and for more than a hundred years blast furnaces have been producing pig iron in the town and the country tributary to it. In a paper read at the meeting of the Institute by the President of the Board of Trade the following statistics were given of the value of iron manufactures in the city for the year ending September 29, 1892:

Reading.

Stoves	$ 659,000
Boilers and flues	323,000
Hardware, locks and butts	1,650,000
Pig iron, wrought iron, pipe and machinery	8,400,000
Iron beams, bridge work and steel	4,000,000
Bolts, nuts, rivets, etc	1,000,000
Total	$16,032,000

These industries give employment to 6,850 people; but they do not embrace all the manufactures of Reading. Other lines of goods produced during the same year, with their values, are shown in the following table:

Hosiery	$ 550,000
Boots and shoes	150,000
Silk and cotton goods	1,725,000
Rope and cordage	600,000
Fire-brick, terra cotta and glass	320,000
Wool and fur hats	3,000,000
Cigars	3,150,000
Total	$9,495,000

More than half of the whole population of the city, I was informed, is supported by its manufactures; and the value of iron products alone, it will be observed, is seventy per cent. of the value of all the products of the iron industries of Ontario in the census year 1880.

Pottstown.

South of Reading about twenty miles, on the line of the Reading Railway, and also upon the Schuylkill river, is the town of Pottstown. It has a population of 15,000, and it is said that almost every workingman in the place is employed either in making or manufacturing iron. There are blast furnaces, bridge works, boiler works, stove works, mill iron works, cut nail works, pipe iron works and steel rail and plate works. The last named establishment was started about thirty years ago in the interest of the Reading Railway Company, and after changing hands two or three times it is now controlled by three men organized as the Pottstown Iron Co., with a capital of $1,000,000. The plant consists of a blast furnace which smelts Lake Champlain and other ores high in phosphorus and silicon, producing 800 tons of pig iron weekly; three basic Bessemer converters, the largest of their class in the United States; a mill for making fire-brick to line the converters; rolling mills for rolling boiler and other plate; nail mills, etc. Two thousand men are employed by this company alone, whose yearly earnings foot up $1,000,000, or one seventh as much as all the wages paid by all the iron industries of Ontario in 1880 and this in one town of 15,000 inhabitants.

There are several other active manufacturing towns in the Schuylkill valley, above and below Reading, one of which is Birdstown, made famous recently by the construction in one of its iron-working establishments of the wire gun—which members of the Institute had the privilege of seeing in a partly finished state.

In the Lehigh valley.

South Bethlehem.

Less than fifty miles eastward of the Schuylkill is the Lehigh river, a tributary of the Delaware. From the gap at Mauch Chunk, where the Lehigh breaks through the Blue mountains, down to its mouth, this river is almost one continuous line of blast furnaces and iron works. Chief among these are the works of the Bethlehem Iron Company, with eight blast furnaces for smelting iron ore (Cuba red hematite, Elba specular and New Jersey magnetic—the latter treated by the Edison magnetic separators), a steel plant with four Bessemer and four Siemens open-hearth furnaces whose aggregate steel-making capacity is 915 tons per day, steel rail mill, and forging and machine shops for the manufacture of guns and nickel steel armor plate for the United States navy. These works give employment to over 4,000 men, and the ground occupied by them extends a mile and a quarter along the Lehigh river by a quarter of a mile in width.

In the Ohio Valley.

Allegheny county.

But the great centre of the iron industry of Pennsylvania as well as of the United States is in the western part of the state, in Allegheny county, whereof Pittsburgh is the chief town. In 1874 there were 11 blast furnaces in this county which produced in that year 143,660 net tons of pig iron, an average per furnace of 13,060 tons; in 1891 the number had increased to 26 and the production to 1,635,531 tons, an average per furnace of 63,289 tons. In 1874 there were also 42 mills and steel works in the county whose total make of crucible, Bessemer and other steels was 23,915 net tons, an average of 570 tons; in 1891 the number of mills and works had grown to 63 and the production to 1,542,921 tons, an average of 24,490 tons.[2]

Pittsburgh.

Further and more imposing evidence of the value of the iron industries of this great centre is found in the assessment rolls of the city of Pittsburgh. For the purpose of levying a business tax, every person or firm engaged in mercantile pursuits in the city is obliged to make each year a sworn return of the gross amount of business done, and the business tax is levied thereon. The following list shows the amount of such business in iron and steel for the year ending 31st March, 1893:

Iron and steel industries of Pittsburgh.

Atwood & McCaffrey, foundry,	$ 308,489
A. M. Byers & Co., iron,	875,832
U. Baird, Machinery Co., machinery,	130,000
H. L. Childs & Co., mill supplies,	215,000
Crescent Steel Co., steel,	420,000
The Harmes Machine Department, machinery,	100,000
The Shook Anderson Machine Co.,	120,000
Singer, Nimick & Co., iron,	1,063,339
S. Severance, spikes,	179,000
Smoky City Boiler Works, boilers,	100,000
The Birmingham Iron and Steel Co., iron and steel,	100,000
Charles A. Turner, mill supplies,	125,000
W. G. Price & Co., plumbers,	225,000
Pittsburgh Supply Co., oil well supplies,	525,000
Riter & Conley, boilers, etc.,	1,016,871
Joseph Woodwell & Co., hardware,	208,701
Neal Bros., iron and steel,	100,000
Oil Well Supply Co.,	300,000
McGinnis, Smith & Co., heating apparatus,	100,000
Apollo Iron and Steel Co., iron and steel,	100,000
Bovaird, Seyfang & Co., oil well supplies,	100,000

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[2] Report of the American Iron and Steel Association for 1891, p. 70.

Iron and steel industries of Pittsburgh.

Pennsylvania Tube Works, iron,	$1,982,040
Robinson Rea Machine Co., machinery,	600,000
The Kelly & Jones Co., steam fitters,	250,000
Bradley & Co., stoves,	100,000
Clinton Iron & Steel Co., iron and steel,	550,000
Frick & Lindsay Co., mill supplies,	100,000
National Tube Works, iron,	200,000
A. Garrison, Foundry Co., foundry,	515,735
Jones & Laughlins, iron and steel,	5,500,000
Wolff, Lane & Co., hardware,	278,486
Bindley Hardware Co., hardware,	600,000
Demmier Bros., hardware,	335,000
Carnegie Steel Co., (Ltd.),	9,582,328
Benny Bros., machinery,	150,000
Babcock & Wilcox, boilers,	200,000
Dilworth, Porter & Co., railway supplies,	1,500,000
Lyle & McCance, hardware,	127,000
Steel and Iron Implement Co.,	100,000
H. K. Porter & Co., locomotives,	437,620
Standard Mfg. Co., plumbers' supplies,	219,059
W. A Giles, engines,	100,000
Nease, McLain & McGinnis, hardware,	120,000
Brown & Co., steel,	800,000
McWhinney & Co., hardware,	200,000
H. Lloyd's Sons & Co., iron,	411,912
Mackintosh, Hemphill & Co., founders,	890,870
Joseph C. Lindsay & Co., hardware,	315,000
Logan, Gregg & Co., hardware,	600,000
James Rees & Son, engines,	161,046
Bissell & Co., stoves,	176,000
Singer Sewing Machine Co.,	100,200
Standard Sewing Machine Co.,	175,000
I. N. Scott & Co., agricultural implements,	200,000
Scoble & Parker, agricultural implements,	205,100
A. Speer & Sons, plows,	184,328
John Hall, jr. & Co., agricultural implements,	130,000
Consolidated Steel Co., wire,	100,000
Standard Underground Cable Co.,	621,901
Zug & Co., iron,	795,700
Schoenberger & Co., iron,	2,613,000
Howe, Brown & Co., steel,	100,000
S. Jarvis Adams & Co., foundry,	180,000
Jarecki Manufacturing Co., pipe,	125,000
Hainsworth Steel Co.,	1,000,000
Cold Rolled Steel Co., steel,	250,000
Hubbard & Co., shovels,	151,714
Hydraulic Machine Co., machines,	100,000
Carbon Steel Co., steel,	400,000
Wm. Clark's Sons & Co., iron,	1,000,000
Iron City Tool Works, tools,	158,136
McCullough, Dalzell & Co., crucibles,	200,000
Pittsburgh Malleable Iron Co., iron,	154,869
Pittsburgh Bridge Works, iron bridges,	271,660
Keystone Rolling Mill Co., iron and steel,	848,550
Linden Steel Co., steel,	698,816
Moorhead, McLean Co., iron and steel,	914,507
A. French, Spring Co., springs,	1,180,000
Westinghouse Machine Co., machinists,	450,000
McConway, Torley & Co., iron,	1,477,000
Schiffler Bridge Co., bridges,	500,000

Iron and steel industries of Pittsburgh.

Seaman, Sleeth & Black, rolls,	$435,000
Marshall Foundry Co., founders,	521,593
R. Munroe & Son, boilers,	250,000
L. M. Morris, foundry,	216,068
Park Bro., & Co., steel,	2,048,546
Pittsburgh Steel Casting Co., steel,	204,072
Scaife Foundry and Machine Co., foundry,	114,738
Totten, Hogg & Co., foundry,	158,300
Oliver & Roberts Wire Co., wire,	1,800,000
Oliver Iron and Steel Co., iron and steel,	2,000,000
Koehler & Strong, scrap,	165,000
Morris & Bailey, steel,	138,000
Phillips, Nimick & Co., iron,	708,975
M. Lanz & Son, nuts, bolts and bricks,	125,000
Lewis Foundry and Machine Co.,	271,677
The Klein Logan Co., tools,	100,000
C. J. Reiling, iron railings,	100,000
Marland, Neely & Co., nuts and bolts,	108,698
Phillips Mining Supply Co.,	100,000
Republic Iron Works,	600,000
Union Foundry and Machine Co.,	150,000

A large business for one city.

Making a total of $59,115,709. But merchants' sales are no doubt included in the list, and so the statement is not to be taken as showing the exact amount of the city's production of iron and steel. Yet after due allowance is made for the business of mercantile houses, the aggregate value of the industries must be a very large sum for one city—probably more than double the value of all the iron and steel products of Ontario establishments in the census year 1880.

GREAT BRITAIN AND THE UNITED STATES.

Growth of pig iron production in the two countries.

The growth of the iron industries of the United States furnishes striking evidence of the progress made by that country during the last quarter of a century, and Great Britain, so long the leader of the world in the production and manufacture of iron and steel, is now reduced to second place. The following table shows how the pace has been kept up by both countries in production of pig iron for a period of twenty years, quantities being expressed in gross tons :[3]

Production of pig iron in Great Britain and the United States during twenty years.

Years.	Great Britain.	United States.	Years.	Great Britain.	United States.
1872	6,741,929	2,548,713	1882	8,586,680	4,623,323
1873	6,566,451	2,560,963	1883	8,529,300	4,595,510
1874	5,991,408	2,401,262	1884	7,811,727	4,097,868
1875	6,365,462	2,023,733	1885	7,415,469	4,044,526
1876	6,555,997	1,868,961	1886	7,009,754	5,683,329
1877	6,608,664	2,066,594	1887	7,559,518	6,417,148
1878	6,381,051	2,301,215	1888	7,998,969	6,489,738
1879	5,995,337	2,741,853	1889	8,322,824	7,603,642
1880	7,749,233	3,835,191	1890	7,904,214	9,202,703
1881	8,144,449	4,144,254	1891	7,406,064	8,279,870

THE INDUSTRY IN GREAT BRITAIN.

An arrest of expansion.

In 1892 the make of pig iron in Great Britain was 6,616,890 tons and in the United States 9,157,000 tons, and it appears likely that the latter country will maintain the supremacy, although it looks as if production would decline 1,000,000 tons this year. In both countries there has been an arrest of expansion, which of course could not long continue at the rate of the last twenty years ; and cautious men may be led to consider whether there is room in the world for many more rival enterprises. The situation in Great Britain is indeed regarded as serious, and the following extract from the address of Mr. Windsor Richards, president of the Iron and Steel Institute, at the May meeting of that body in London, may be accepted as a trustworthy presentation of it:

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[3] Mineral resources of the United States, 1891, p. 52.

Richards.

"The present meeting is held under circumstances of great depression and gloom for the iron and steel trades. The year 1892 was, in many respects, one of the very worst those industries have ever known. The production of pig iron fell off to the extent of over 600,000 tons. The production of wrought iron and steel was also much under that of some previous years. The most serious falling off however was in the production of steel rails. The export of rails in 1892 was not much more than one-half that of 1890, while the exports of 1890 were much under those of some previous years. The total falling away in our exports of metal and machinery in 1892 as compared with 1891 amounted to over seven millions sterling. One characteristic of the iron industry of the past year has been the great falling off in the quantity of pig iron made from English ores. The imports from Spain during 1892 amounted to $3\frac{3}{4}$ millions of tons, equal to a production of 1,800,000 tons of pig iron. The total quantity of pig iron made in this country in that year was 6,616,890 tons, so that 26 per cent. of the whole production was made from imported ores.

A period of depression and gloom.

Imports of ores from Spain.

"It is remarkable how all the principal iron making districts have of late years increased their consumption of imported ores and reduced the use of home ores. In Scotland the make of well-known brands of Scotch foundry iron has been largely reduced from year to year, until now more than 24 per cent. of the production is obtained from foreign ores. South Wales has practically ceased raising iron-stone and depends almost entirely on foreign supplies. Cleveland has immense quantities of phosphoric iron-stone at its door, cheaply won, but 20 per cent. of its total make of pig iron comes from ores carried more than a thousand miles. Even Lancashire and Cumberland, with hematite ores of the highest quality close at hand, have of late years extended their use of Spanish ores. Is it possible for the north of Spain, which in 1892 supplied us with $3\frac{1}{4}$ millions of tons of ore, to maintain that output for a much longer time? It is generally thought that the most valuable and extensive deposits are being rapidly exhausted, and that some of the most productive mines are not likely to last more than a few years longer. Last month I visited Bilbao and made careful enquiries from competent authorities on the spot, and learned that, with the exception of the large mines owned by the Orconera and Franco-Belge companies, there are no very extensive mines left to be worked. Indeed were it not for the recent successful calcination of the spathic ores which underlie the Rubio ore, the duration of the district at the present rate of output—4 million tons per annum—would have been within measurable distance; but there are very large deposits of spathic ore, the depth and extent being as yet unproved. Calcining operations in the near future will be largely carried on, making the spathic ore which in the raw state contains 43 per cent. of iron, and 25 per cent. carbonic acid, give in the calcined condition 58 per cent. of iron, thus making a very valuable mineral, having only 2 per cent. of moisture as received. Calcining kilns are already erected, one large kiln economically and effectually calcining 1,500 tons of raw ore weekly. It seems probable that this successful dealing with the spathic deposit will extend the life of the district fully ten years. It must be understood however that this length of life does not apply to the Orconera and Franco-Belge properties.

Decrease in consumption of home ores.

Exhausting the Spanish deposits.

"There are large deposits of ores free from phosphorus in the neighborhood of Seville and in the south of Spain that will become available, but considerable sums of English money will have to be expended in opening out the mines and conveying the mineral to the ship; but in the words of Mr. Gill of the Orconera Company, who has seen all the recently discovered large

Richards.

deposits, there is as yet only one Bilbao. Under these circumstances it is natural that our attention should be arrested by the enquiry, whether, if the Spanish supplies were to be suddenly cut off, we could depend wholly on our home mines. The west coast has raised 2¾ millions of tons of ore free from phosphorus, and could most probably increase that quantity to produce 1½ millions of tons of pig iron should the demand arise.

Utilizing the phosphoric ores.

"During the twelve months ending December, 1892, the quantity of basic steel made in England was 406,839 tons, of which 108,056 tons were open-hearth steel. In Germany and Luxemburg 2,013,484 tons of steel were made from phosphoric ores, of which quantity 186,252 tons were open-hearth, the balance being basic Bessemer steel.

Value of the basic process to the British mine owners and iron makers.

"Very much more prejudice has existed in England than on the part of continental buyers against the use of steel made by the basic process. This seems only natural when no difficulty existed here in procuring ores free from phosphorus, and in the event of foreign supplies being cut off such prejudice would doubtless quickly disappear. There need therefore be no apprehension of our being able to supply all the iron and steel we may be called upon to produce. Indeed the great trouble seems to be that of being able to procure sufficient work to keep our large establishments employed. We could quickly make ourselves independent of foreign supplies of ores, except in the manufacture of high percentages of manganese in spiegeleisen and ferro-manganese, and in this respect we are entirely dependent on foreign countries, the English spathic ores not being rich enough to give above 10 per cent. manganese in spiegel."

And in the close of his address Mr. Richards said :

Advantages of better organization and improved mechanical arrangements.

"All those who manage steel works either for the production of rails or ship plates, pride themselves on their power of organization, not only to increase output, but to maintain high quality. Then again the ingenuity of our engineers has been called into play to substitute mechanical arrangements for the so-called cheap labor. One cannot fail to observe how few men are employed in a mill turning out 5,000 tons of finished rails weekly. The heavy ingots are conveyed by small locomotives to the rolling mills, are moved to and from the several grooves of the rolls by live rollers, are turned over and carried sideways, rails are rolled in 155 feet lengths, are carried to the saws, are cut, are conveyed away, are placed on hot banks to cool, all by ingenious mechanical contrivances; the same may be said of plate rolling. It is only when the material becomes cold that labor becomes expensive and troublesome; but the more difficult it becomes the surer will machinery be devised to dispense with it.

But there is another side.

"So successful have we all been in economically increasing production that we have inundated and swamped the markets for the time being ; at present and for some time past there is not enough work for half the steel-producing power of the country. Thus we go on and we look about in vain for new markets. We compare America with 60 millions of people, having 175,000 miles of railway, with India having 250,000,000 of people and only 17,000 miles of railway, and wonder why under our sway it develops at such a wretchedly slow rate. Where is the trade to come from to keep our workmen employed and our establishments in operation? No one seems to be able to answer this question; but we know that we have had many serious depressions before—though none seem so deep, so prolonged as this. The iron and steel trades may be likened to Pandora's box, from which, once filled with all good things and all bad, everything escaped, the good things back to heaven, and the evils to infest and plague the earth ; but there is still left to us that which never deserts us, the inestimable blessing—Hope."

And what are the lessons of the situation for us? Not simply to fold our hands, nor to push a business beyond the limits of our requirements. But rather to undertake that which is nearest us, what we most need, and what we can engage in with the best assurance that the effort will not be lost.

VI.

LOCATIONS FOR PIG IRON PRODUCTION.[1]

By John Birkinbine, ex-President American Institute of Mining Engineers.

Influence of improved processes in developing mineral resources.

The advances which brought the United States to first position as a producer of iron ores, pig iron, Bessemer steel and other products naturally drew attention to the importance of developing mineral resources lying dormant, and of establishing industries for the production and manufacture of iron and steel in new locations. To secure this, various methods for encouraging capital to embark in new enterprises have been employed, and the erection of blast furnaces for the production of pig iron has attracted first attention. If the statements of advantage claimed for certain locations as set forth in newspaper articles, or by special announcements in circulars, were all true, the United States would be unusually favored both by the number and the generous distribution of sites which are peculiarly adapted for the production of pig iron, and sections of the country now sparsely populated should develop rapidly into series of adjoining commercial metropoli.

This country of great resources has before it great possibilities, and the liberal distribution of deposits of mineral undoubtedly offer numerous available sites for the establishment of iron-producing or iron-manufacturing plants, while an augmenting population will seek new industrial centres ; but the available locations for successful iron manufactures or for future cities are by no means as numerous as the published statements referred to indicate. It is not necessary to assume that all or most of such statements were made without a basis, for in a large number of instances, and possibly in most of them, there have been apparent reasons leading to the assumption that peculiar advantages are possessed by special locations.

ADVANTAGES OF LOCATION.

Conditions of good location for a blast furnace.

Iron ores, fuel or flux, or all three, may occur within convenient distance of a site for a projected blast furnace, and such site may have the added advantages of ample labor at satisfactory prices, good transportation facilities, etc., yet the construction of a blast furnace for the production of pig iron may be followed by financial disaster. The quality of the ore, coal and limestone, the quantities which can be advantageously assembled at the point for producing the metal, the method of winning these raw materials from the ground, and the cost of mining and preparing them for the furnace must enter into any estimate in which the advantages of erecting a new smelting works are considered in comparison with those existing elsewhere.

A convenient market for pig iron.

A most important consideration is a convenient market for the product, for although improvement in railway construction and operation and competition between different lines of traffic have so reduced the transportation charges that localities hundreds of miles apart are now as close competitors as were those in former years which were separated by but a few miles, the advantage of consumption close at hand is by no means a small factor in determining the financial success or failure of an iron-producing enterprise.

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[1] Reproduced from the Engineering Magazine for March, 1893, with the kind permission of the writer and publishers. Mr. Birkinbine is one of the first authorities in the United States on the subject of the iron industry.

Town-booming schemes to be avoided.

Of the numerous schemes in which blast furnaces have been used as foundations upon which to start real estate speculation or town "booms," some have had little if any substantial basis; others have possessed one or more of the factors which are essential for the economic production of pig metal, and some which have been started and progressed well on towards completion, have already demonstrated the error of attempting to produce pig iron, or of using a blast furnace as the initiative industrial feature for the establishment of manufacturing centres where other conditions do not demand such centres.

The employés about a blast furnace are not as a rule the best calculated to form nuclei of large populations. Outside of such as are paid salaries, few receive compensation above that given to ordinary labor (except for the extra hours per day which they work), and the labor about blast furnaces cannot be considered as fixed or permanent. Recognizing this, some of the promoters of town ventures secured the promise or the actual establishment of industries which would use a larger number of skilled employés, and generally such as obtained better wages than the blast furnaces offer. Some of these advanced industries rely upon the product of blast furnaces for their raw material, while others may be entirely independent of the furnaces. The industrial plants proposed or erected may either embody new equipments or those moved from other sites and renewed in appointment so as to be creditable to any locality; but in other cases investments have been encouraged by the bodily removal to new sites of plants which have outlived their usefulness in their old locations, largely on account of antiquated equipment to which little or no addition was made for the changed conditions. Disaster may be expected to follow enterprises established at locations which do not, as far as practicable, possess advantages equal or superior to others which have been in operation elsewhere for a term of years.

A new industry, or the opening up of a new industrial district, must meet competition, and break into established trade held by older concerns, a fact which often seems to be lost sight of by those who press the claims of some locations. Under ordinary conditions a new business venture is sufficiently handicapped in securing an entrance into active trade, and needs all the advantage which good equipment, substantial construction, economical management and good financiering bring to assist it in competing for a share of business.

The prime considerations of suitable locality.

If a blast furnace were necessarily the best starting point for an industrial town or city, the number of such settlements in the older iron-producing districts would be greater than they are, but any one conversant with the location of existing blast furnaces recognizes how many of these, although they have occupied the same location for a number of years, and may have been well managed and operated with skill, have gathered scarcely more than a hamlet about them. On the other hand, a number of instances could be quoted where towns and cities have developed from a single forge or blast furnace, which was erected in such location as to have the advantage of good and cheap raw materials and an ample market; in fact some new important settlements originated from the location of plants which did not possess all of the advantages named. But the exception proves the rule, that the future advance in real estate or the prospective establishment of towns or cities should seldom have a prominent place in estimates when a location is to be chosen for the production of pig iron. The prime considerations should rather be the quantity, quality and cost at which raw materials and labor can be assembled, the character of pig iron which can be made, and the market offered for its sale.

THE LESSONS OF EXPERIENCE.

Elements of success and failure.

An examination of the development of the pig iron industry of the United States demonstrates the extent to which success has been and will continue to be affected by location, and a retrospect of the history of existing and apparently prosperous furnaces shows how many have met with financial difficulties, necessitating change of ownership or of management, while today close attention and economy are essential for their continued activity.

Quality, quantity and cost of raw material.

If abundance of raw material is required there would be no necessity for the number of idle iron ore mines which today are scattered through some of the older iron-producing districts, convenient to fuel supplies; but the quality and the cost of winning the ore, as well as the quantity, must be considered. The material won from some of these idle mines was of a very satisfactory character for the production of metal in demand, until changed conditions of trade required ore of different composition; although some of the mines which are inactive produce ore of a quality equal or superior to that largely used in other sections of the country where the deposits are newer or can be worked more cheaply. Other mines have been wrought until the extraction of the ore renders insufficient profit to permit competition with richer ores brought from long distances.

Cheapness and supply of raw materials not alone sufficient.

If the abundance of satisfactory fuel obtained close to the plants were the chief necessity for economical operation of blast furnaces, and if this could not be off-set by other advantages there would be no excuse for the magnificent iron and steel industry centered at Chicago; for there the blast furnaces have no raw materials near at hand, except the limestone, and the per diem rates of labor average higher than in some other sections of the country where pig iron is made. On the other hand, if an abundant supply of iron ore off-set the advantage of near fuel and a good market, the enormous output of the blast furnaces in the vicinity of Pittsburgh would seem to be produced at a decided disadvantage, for with the exception of the local mill cinder and a partial dependence of some outlying furnaces upon local carbonates and brown hematites, all of the iron made in Pittsburgh and vicinity, in the Shenango valley of Pennsylvania and the Mahoning valley of Ohio, as well as that produced about Wheeling, West Virginia, and Johnstown, Pennsylvania, is obtained by smelting iron ores brought from lake Superior.

Decline of number of furnaces, and increase of production.

The surroundings which several decades ago made a location advantageous for the smelting of iron ores may have less weight in determining the erection of a blast furnace plant at the present time, several causes combining to affect the influences which certain conditions exert. Owing to the increased production of blast furnaces now constructed, due to the average size, the general use of richer ore mixtures, and the more intelligent management which is bestowed upon the operation of the existing plants, the number of blast furnaces in the United States, either active or likely to be in operation, has declined since 1881, when 717 were recorded. In 1890—the year of our greatest pig iron output—but 562 furnaces were on the active list; of these but 311 were in operation at the close of 1890, being a smaller number than in any of the preceding twelve years with but three exceptions (1883, 1884, 1885), in each of which the pig iron output was less than half of what it was in 1890. The production of pig iron in the years 1891 and 1892 did not reach that of 1890, but owing to some new plants having been completed or blown in the number of furnaces was slightly increased. The record shows that in 1890 there were 562 furnaces on the active list, with an output of 9,202,703 gross tons; in 1891 the furnaces numbered 569, and the output was 8,279,870 gross tons; and in 1892, 564 furnaces were reported, all of which however were not in operation, the tonnage for the year being 9,157,000 gross tons.

Economy of centralizing the industry and increasing the capacity of furnaces.

Therefore an increased output of pig iron is secured from a decreased number of blast furnaces; and as there is a growing tendency to centralize industries (groups of furnaces under one management becoming more common) there must necessarily be fewer specially available locations at the present time than formerly.

A quarter of a century ago a blast furnace which averaged from thirty to thirty-five gross tons of pig iron daily was recognized as of large size and doing excellent work. Now, a production exceeding two hundred tons per day by blast furnaces is not considered remarkable, and where a number of large structures are combined under one management they present a problem for assembling raw materials vastly different from that of the average furnace twenty-five years ago.

Large plants demand large basis for supplies.

With the perfection of mining appliances, the intelligent management of mines, the facilities for winning or transporting ores, fuel and flux, there may be really less personal supervision necessary in assembling the raw materials for one of the large plants than was demanded of the managers of the smaller ones, who had to rehandle the material and furnish at least a part of the transportation. But for the larger plants the basis of supply must necessarily be larger. Increased tonnage of ore, fuel and flux demands greater available supplies, and hence dependence upon merely local deposits of iron ore is now uncommon. Advances in the technology of blast furnace operation and the increasing demand for metal of special chemical compositions also affect the reliance which may be placed upon local deposits of iron ores, for blast furnace managers must work within narrow limits as to the character of pig iron made. Hence the location selected for plants should be accessible to supplies of ores from which such mixtures can be made as will permit of producing not only the grade but the quality of metal required, at prices which admit of manufacturing it advantageously so as to meet the available market.

INFLUENCE OF THE BESSEMER PROCESS.

Development of the lake Superior iron regions.

The development of the lake Superior region, which up to the close of 1892 contributed more than 74,000,000 gross tons of iron ore, is not alone due to the high percentage of iron representing the average of the ore produced, for the variety and composition of the ores which have been mined, and which fit them for different purposes, have had a marked influence in this development. In view of the generally-accepted belief in the prime necessity of ores of Bessemer grade, it may sound peculiar to assert that had all of the iron ores won from the lake Superior district been sufficiently low in phosphorus to be acceptable for the production of pig iron for the Bessemer process, the development of this district would have been less rapid than it has been as a producer of the various grades of iron ore.

Increase in make of Bessemer iron and steel.

To emphasize this fact it is unnecessary to go further back in history than a few years, for if an interval of five years ending December 31, 1891, be taken and the proportionate amounts of Bessemer and other kinds of pig iron produced are tabulated, such statement shows that in the year 1887, 44.81 per cent. of the total pig iron output of the country was of the Bessemer quality. In 1888 this percentage was reduced to 40.65 per cent., the total output of pig iron being practically the same as in 1887. In 1889 there was an increase of more than 1,000,000 gross tons in the annual production of the country, and in that year the quantity of Bessemer pig iron made was 41.45 per cent. of the total. Another increase of more than 1,500,000 tons brought the pig iron made in the United States in 1890 to a total of 9,202,703 gross tons, of which 44.47 per cent. was of Bessemer quality. The year 1891 showed a decline from the production of 1890 of nearly 1,000,000 tons, and in that year 41.94 per cent. of the total was of Bessemer grade. The figures which have just been compiled for the year 1892 indicate that out of the total production of pig iron, 9,157,000 gross tons, 48.53 per cent. was of Bessemer quality.

Effect upon location of furnaces.

The growth of the Bessemer steel manufacture in this country has been phenomenal, continuously increasing in twenty-five years from a product of 3,000 tons to one of more than 14,000 000 gross tons, such an industry necessarily exerting a very marked influence upon the location of the furnaces which supply the metal for it, and upon the development of iron ores which are used in these furnaces. It is probable that the majority of persons suppose the great steel works at Chicago, Pittsburgh, Baltimore, Harrisburg, Johnstown, Scranton, Bethelem, Troy, etc., to have been located on account of blast furnaces connected with them. It is undoubtedly true that some of these plants owe their existence to an original forge or blast furnace, but an investigation will show that, properly speaking, the existing blast furnaces were located at these points because of the steel works, and are established so as to supply to large industrial plants the raw material upon which they must depend.

INFLUENCE OF FOUNDRY AND ROLLING-MILL TRADE.

Convenience to market affects location of furnaces producing foundry and mill pig.

In a similar manner it may be shown that most of the blast furnaces which are producing pig iron of grades particularly adapted for the foundry or rolling-mill trade owe their situation more to convenience to a market for the product, than to being specially near to supplies of fuel or of ore peculiarly suited for the product made. Taking the five years 1887, 1888, 1889, 1890 and 1891, the figures show that, while the blast furnaces located in the vicinity of Pittsburgh and in western Pennsylvania and eastern Ohio increased their total output of pig iron nearly 50 per cent., much of this growth was in the production of Bessemer pig iron, the annual output of which augmented nearly 80 per cent. But on the other hand, while the state of Illinois increased its total production of pig iron one-third, its output of Bessemer was augmented but one-tenth in the five years named: that is, in spite of the state of Alabama trebling its output of foundry and mill pig iron in five years, and other southern states adding to the volume of this class of metal, the state of Illinois, with its large steel industry, accessible to liberal supplies of iron ore suitable for producing Bessemer pig iron, increased the quantity of ordinary pig metal produced three times as rapidly as that used for Bessemer purposes. The advance figures of pig iron production for the year 1892, just published, show a decided increase in the quantity of Bessemer pig iron made, the tonnage and the proportion of this metal being greater than in any other year. At present writing the relative amounts for specific districts cannot be given exactly, but a comparison of the records of the years 1887 and 1892 indicate the following: In the Pittsburgh district the output of Bessemer pig iron was more than double, while the total of all kinds of pig metal increased less than 80 per cent., showing a gain in Bessemer pig iron at the expense of mill and foundry iron. Similarly the greater portion of the advance in Illinois last year was in Bessemer pig iron, the increase in six years being 88 per cent. in the production of total pig iron, and 63 per cent. in that of Bessemer pig iron. Alabama's product, none of which was Bessemer pig iron, was two and one-half times greater in 1892 than in 1887.

GENERAL CONCLUSIONS.

Quantity, quality and market cost are the essenc of suitable location.

The influence of location upon the pig iron industry would seem therefore to be based not only upon the possibility of assembling the raw materials, but also upon the opportunities for marketing the product advantageously. A blast furnace may act temporarily as a sign board for a real estate "boom," although its operation may be at a financial loss, but ultimately dividends or profit must come from it, or failure will be written against it. A smelting plant may instil life into a district, and cause the exploitation of old or the development of new iron ore mines; but unless the ore supply is ample, its quality such as is in demand, and the winning of the ore at low cost can be carried on for a term of years, the success of the enterprise is problematical.

The continued existence and evidences of prosperity of some of the plants located in sections of the country where the use of local ores is practically abandoned, and the late reconstruction of some of these plants to depend upon ores brought from distant points, indicate the importance of convenience to market and an established trade. The enormous output of iron ore from the lake Superior district, which is conveyed by rail from the mines to extensive shipping docks, loaded on vessels which carry it to equally extensive receiving docks, and again transported on cars for points of consumption from 300 to 1,000 miles from the mines, demonstrates the growing appreciation of high-grade ores.

A tendency to centralization.

The extensive plants distant from ores or fuel, or both, which have been established near important commercial centres, and the concentration of allied industries at these points, evidence the general tendency of iron production to become centralized in a comparatively small number of locations.

As the rapid increase of the population of the country changes the requirements of different sections, and consumers of iron and its manufactures multiply rapidly, deposits of ore yet unexploited await the local demand for metal which will bring these ores and fuel for smelting them together. It is probable that some future industries will occupy territory which years ago or quite lately was developed in part by ventures which failed because they were in advance of the necessities of the times ; the fact that some of these earlier attempts proved disastrous may act as a check on improvements in sections which would sustain a considerable and increasing industry.

Premature enterprise.

Deception as to the quantity of manufactured material required in certain districts has cost enthusiastic projectors much loss, and in some cases has condemned by premature efforts enterprises which would prove successful later. The apparent quantities of iron used often offers inducement to believe that a large local market exists, but these quantities when analyzed show that such varieties of metal must be made, and that so many minor industries must be established to transform the crude material into the merchantable shapes demanded, that years elapse before new blast furnace plants overcome the difficulties which await them.

Influence of progress in the metallurgy of iron.

The requirements of the steel works for iron of special composition has been followed by foundries and mills making more rigid specifications ; and this in turn has influenced the ores in demand by blast furnaces. Progress in iron metallurgy has shown where economies can be introduced which reduce the fuel and labor per ton of iron made, and an appreciation of the relative values of different percentages of iron in ores has increased the demand for those which may be classed as rich in iron. Each year shows an increase in the average percentage of iron in the ore mixtures used in American blast furnaces and longer distances covered by the rich ores in reaching points of consumption. It is probable that future advances may be in the direction of conveying fuel to meet these ores, particularly if the meeting points furnish good market facilities for the product, and that the use of lean ores will be chiefly in connection with great local advantages as to the other features which go to make up successful blast furnace enterprises.

VII.

NICKEL AND COPPER.

Ores of nickel and copper in the Sudbury district.

The Sudbury district continues to be searched for copper and nickel, and discoveries of the ores of these metals continue to be made in various localities. The area is now shown to be of large extent; but the limits of it are not defined; neither is it certain that every body of ore even in territory most familiar to prospectors has yet been discovered. The close growth of small timber on tracts swept over by forest fires twenty or twenty-five years ago hide out-croppings of ore, or the familiar surface signs by which its presence is indicated, from any but the most careful examination, while the alternation of rocky range and swamp land greatly increase the difficulty of traversing the country. It is not unlikely therefore that the diligent prospector will be rewarded by new and perhaps important discoveries of ore for some time to come at points convenient to existing railway lines, and that it will be many years before the whole of the nickel and copper-bearing formations are delimited on the maps of the country. But what is already known of the extent of the ore bodies, both by deep workings in the mines and the test pits of exploring parties, leaves no doubt in the minds of practical men who have examined the district that nickel and copper are there in illimitable amount; and the strong probability is that a hundred years hence the supply will appear to be as inexhaustible as it is to the miners and explorers of to-day. It is likely too that other parts of the Province besides the Sudbury district will be found to yield both nickel and copper. The Huronian belt in which the known deposits lie extends from the north shore of lake Huron across the Province to the Quebec boundary at Abbitibbi lake, a distance of 300 miles, the breadth of which is about 75 miles,—but embracing some Laurentian areas. On the shore of lake Huron copper and nickel were discovered in this belt nearly fifty years ago, and far to the northeastward of Sudbury prospectors report that they have observed indications of the same ores. Of course the character of the Huronian rocks is not uniform over a wide extent, and great local differences may be looked for in an area of 22,000 square miles; but it is certain that all the chalcopyrite and nickeliferous pyrrhotite of this great Huronian belt are not confined to one or two townships in the vicinity of Sudbury. During the past year too a discovery is reported on Lake-of-the-Woods which may be only the beginning of valuable finds there. At any rate further prospecting in that region ought to be encouraged by the history of exploration in the Sudbury district. Interest has also been recently revived in the Bruce Mines locality, and possibly the old workings there which were carried on with so much spirit for thirty years—beginning with 1846 and ending with 1876—may once again become the scene of an active industry. It is by no means certain that those mines could not be made to pay under modern methods of working and with the facilities for transportation which are now provided.

Extent of the Huronian belt in which the ores are found.

Discovery on Lake-of-the-Woods.

Bruce Mines.

COPPER ON POINT MAMAINSE.

Copper ore and native copper on Point Mamainse.

A locality of bright promise is Point Mamainse on the east coast of lake Superior, where development work has been undertaken during the past year, and to which reference is made in the Report of the Inspector of Mines, who visited the place last summer. The following interesting account of this property and the nature of the work undertaken upon it was furnished me last November by H. S. Sibley of Detroit, in the course of an interview:

Sibley.

"I am one of two trustees holding for a syndicate the Mamainse copper locations on the east coast of lake Superior. They consist of 11,200 acres, Sibley.

Extent of the locations.

Exploring with diamond drill.

Sinking an exploration shaft.

which were purchased from the Crown by the Montreal Mining Company in 1856. A little prospecting was done by Joshua Coatsworth about 1858, and afterwards by the Ontario Mineral Lands Company in the winter of 1881-2. Two small exploring shafts were sunk in the conglomerate on the Pancake location. This bed is 9 to 14 feet thick and carries one to two per cent. of native copper. No further work was attempted until the autumn of 1891, when a party with Captain T. H. Trethewey in charge was sent up to explore with a diamond drill outfit. Drilling was carried on upon five veins to the extent of 3,643 feet, and to 357 feet on a conglomerate bed; the cores showed native copper to depths of 40 to 320 feet in the veins. The veins vary in width from 3 to 12 feet, and consist of calcspar and fragments of wall rock (conglomerate and trap) cemented by native copper. Jasper pebbles are also found in the veins. In 1892 drilling was continued until July, but in June work was commenced on an exploring shaft 7 by 9 feet, which was carried down upon one of the veins to a depth of 32 feet. A stream runs along the course of this vein, crossing and re-crossing it at intervals, so that some difficulty was experienced in keeping the shaft free from water with the methods at control. The ore was found to be rich throughout the whole depth of the shaft, and so satisfactory was it that the men were set at work to strip the vein and make open cuts upon it at various points for a distance of 1,600 feet; the width varies from 3 to 6 feet. The course of this vein is a little west of north and lies between amygdaloid trap on the west side for foot wall and conglomerate on the east side for hanging wall, showing a lateral thrust of 90 feet About five tons of ore was taken out of the shaft, from which fair samples were selected and sent to the St Louis sampling and testing works in August. Following is the report made to me by the manager of these works:

'St. Louis, Mo., September 20, 1892.

'H. S. Sibley, Esq., 80 Griswold street, Detroit.

Analysis of the ore

showing a high percentage of copper.

'Dear Sir,—We have just wired you results of tests of the two lots of copper ore sent us, and we herewith present more fully the details of these tests. The larger sample lot, weighing 1,196 lb. net, was crushed in jaw crusher and run through our 3-stamp battery to separate the rock material and finer copper from the coarse metallic copper. The former as tailings were carefully saved in settling tanks, weighed and sampled and assayed for copper and silver. The coarser metallic copper was carefully sampled down three times to secure three separate samples in order to secure a better check on a difficult material to sample. These three samples were assayed for copper and silver separately and the average taken. As a result of all these operations we find the lot to contain 22.78 per cent. metallic copper and a trace of silver. The other sample lot marked gray ore was crushed in a jaw crusher and rolls until it was fine enough to quarter down to sample. An assay for copper and silver gave the following results: Copper, 18.84 per cent.; silver, 1.8 oz. per ton. We regret that owing to the great difficulty in handling such obstinate material we have not been able to give you results sooner, but trust they will be in time to serve your purpose. Yours truly,

'St. Louis Sampling and Testing Works,
'William B. Potter, Manager.'

Sinking the shaft to a depth of 500 feet.

"The gray copper ore is found generally throughout the vein, but chiefly on the foot wall. The native copper ore is generally disseminated from wall to wall. The trustees have given an option on the property to a Detroit syndicate, by whom operations to sink the shaft to a depth of 500 feet will be carried on through the winter. This work it is hoped will be finished in ten months. Air compressor, hoisting engine, boilers, drills and all necessary supplies were delivered at Point Mamainse on the 17th of November."

Geological formation.

The geological formation at Point Mamainse is the same as that of Keweenaw point on the south shore, where are located the great copper mines of Michigan.

The Production of Nickel.

Output of the Sudbury works.

The quantities of ore mined and smelted in the Sudbury district last year are given on page 8 of this Report. The product of the furnaces, consisting of ordinary and bessemerized matte, held of metallic nickel 2,082 tons, of copper 1,936 tons, and of cobalt 8½ tons. These figures of metallic contents are estimates computed from the analyses of sample lots, and are no doubt as accurate as such estimates can be made; they are so accepted by sellers and buyers of the matte. The whole matte product of the several furnaces is sent out of the country to be refined, some of it to Great Britain, some to France, but the greater portion of it to the United States. There is in the latter country an extra demand owing to the use of nickel as an alloy with steel in the manufacture of armor plate for battle ships. In 1891 the quantity of nickel contained in Canadian matte smelted in the United States was 2,000,000 pounds, some of which went into the general market, but a considerable amount of it was the matte purchased by the Navy Department. This latter is worked up by contract, the copper being taken out and the nickel and iron being left as oxide, in which form it is delivered to the steel works at Bethlehem and Homestead to furnish the nickel for armor plates.[1] There are at present four smelting or refining works in the United States for treating nickel and copper mattes, viz.: The works of Joseph Wharton at Camden, New Jersey; those of the Orford Copper Co. at Constable Hook in the same state; those of the Emmens Metal Company at Youngwood in Pennsylvania; and those of the Canadian Copper Co. near Cleveland. Until recently Joseph Wharton had a monopoly of nickel production in the United States, and his mine at Lancaster Gap in Pennsylvania produced the bulk of the ore treated at his refining works But since the beginning of 1889 Sudbury has been brought into competition with it, and the result has been the closing at the end of 1891 of the Lancaster Gap mine. So that in 1892 the product of the nickel smelters will be all from Canada, except occasional small amounts from Mine LaMotte, and from Nevada, Oregon and the mines near Webster, North Carolina.[2] The following table gives the total nickel product of the United States for the sixteen years 1876-91, together with the value of the same and the value per pound:

Markets for the matte.

Refining works in the United States.

The Gap mine closed down.

Nickel production of the United States.

Year.	Quantity.	Value.	Value per lb.
	lb.	$	cents.
1876	201,367	523,554	260
1877	188,211	301,138	160
1878	150,890	165,979	110
1879	145,120	162,534	112
1880	233,893	257,282	110
1881	265,668	292,235	110
1882	281,616	309,777	110
1833	58,800	52,920	90
1884	64,550	48,412	75
1885	277,904	179,975	64.4
1886	214.992	127,157	59.14
1887	205,566	133,200	64.75
1888	204,328	127,632	62.46
1889	252,663	151,598	60
1890	223,488	134,092	60
1891	118,498	76,024	64
Totals	3,087,554	3,043,509	98.57

Mineral Resources of the United States, 1891, p. 167.

[2] Ib. p. 167.

A significant comparison.

Fall in prices, and the cause.

The nickel contents of the matte produced at Sudbury furnaces last year therefore are greater than all the nickel produced by United States mines in sixteen years by 1,076,446 pounds. It will be observed also that the price of nickel as computed from values of the United States product has fallen very materially since 1876. This drop is due chiefly to the working of the New Caledonia mines, by which the world's production was largely increased. Canadian nickel has had a less noticeable effect, but no doubt for the reason that price is determined now mainly by the cost of refining. Yet the ruling price in the London market last year was about 42 cents per pound, while in the New York market in the latter part of the year quotations when given ranged from 48 to 52 cents—the protection afforded by the United States tariff of 15 cents per pound serving to keep up the higher rate in that country. But these prices are presumably for commercial nickel, which is not pure fine.

Methods of Extracting the Metal.

The wet process as described by Prof. Roberts-Austen.

There are numerous methods already patented for treating ores containing nickel, copper and cobalt, but almost all of them follow the wet process. In a subsequent section of this Report details of treatment are given in a paper by Mons. Levat, and here it may be interesting to give a general description of the process from the pen of Prof. Roberts-Austen, of the Royal College of Science, England :

Roasting the ore.

Dissolving oxides with acid.

"The wet method for the extraction of nickel and cobalt from a complex regulus or arsenide consist, in the first place, of a roasting operation having for its object the volatilization of the sulphur and arsenic, and it may be antimony, and the conversion of the iron, nickel, cobalt and other metals present into oxides. Ferric oxide formed in this manner at a high temperature is but little soluble in acids, whilst the other oxides may be readily dissolved. On treating the roasted material repeatedly with hydrochloric acid or with dilute sulphuric acid, a residue is obtained containing but little or no cobalt or nickel, and consisting mainly of ferric oxide. Some iron will however have passed into solution. Should the solution contain lead, bismuth or copper, these metals may be precipitated by sulphuretted hydrogen ; but it is customary to precipitate the copper at a later stage of the operations. The bismuth too may be precipitated from a hydrochloric acid solution by dilution with water.

Precipitating the iron.

"The next operation consists in the precipitation of the iron. Any ferrous oxide which may have passed into solution is converted into ferric oxide by careful addition of chloride of lime, followed by the addition of lime, which precipitates the iron. Arsenate of iron is at the same time also precipitated if arsenic is present. Should the temperature of the solution exceed 40°c. some nickel and cobalt are precipitated, as also is some copper.

"Instead of an addition of lime as the precipitant, caustic soda or sodium carbonate is occasionally employed to prevent the precipitation of calcium sulphate when working with sulphuric acid solutions. Care must be taken to avoid using an excess of the precipitant, as the precipitation is a fractional one, and as soon as the iron has been precipitated oxides of the other metals present begin to be thrown down.

Precipitation of copper,

cobalt

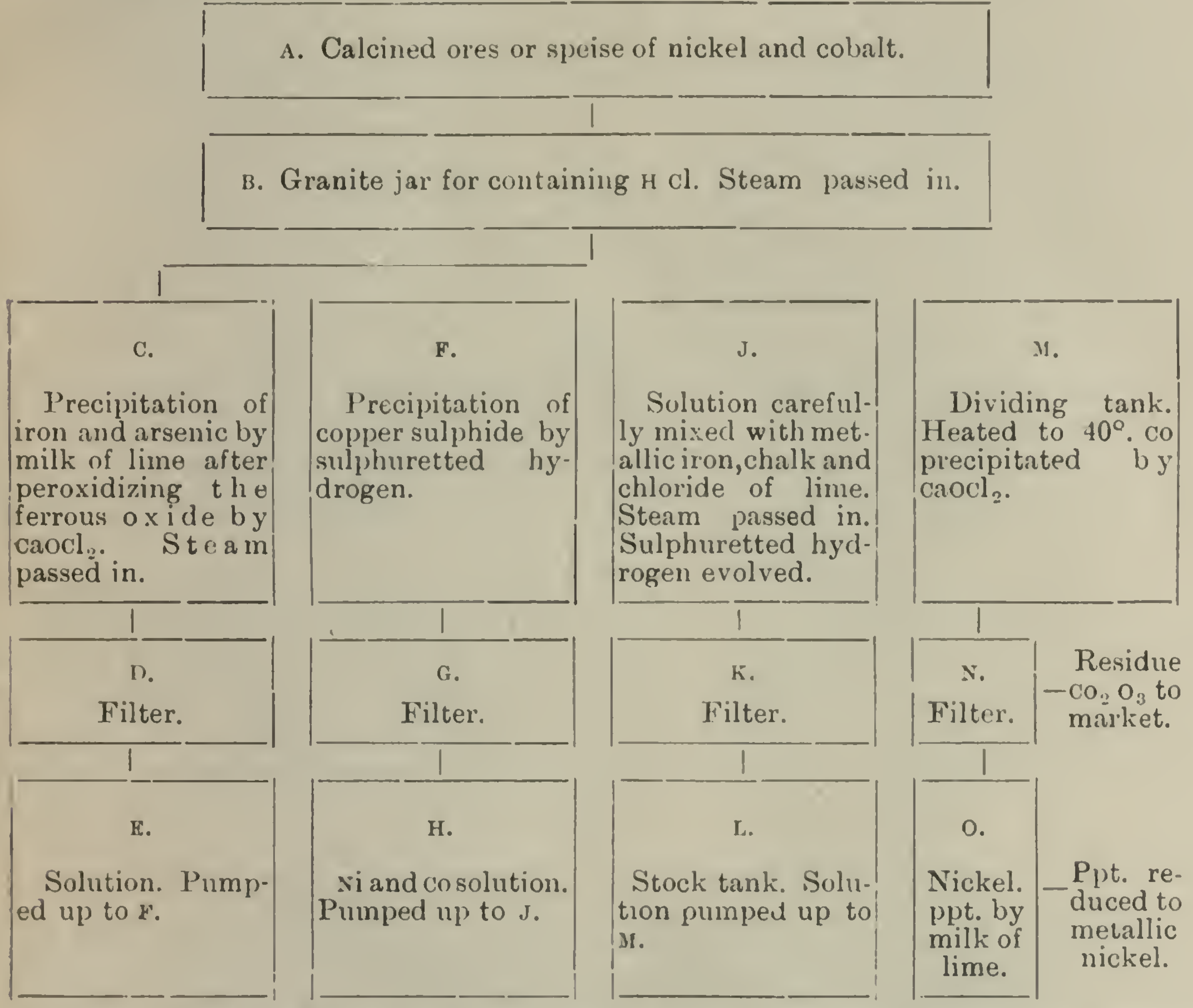
"The next stage of the process consists in the precipitation of the copper. This is effected by raising the temperature of the solution to 70°c., and then precipitating the copper by the careful addition of either calcium carbonate, milk of lime, or a solution of soda. If an excess of the precipitant is employed, nickel will be thrown down. When a test with potassium ferro-cyanide shows that the whole of the copper has been thrown down, the cobalt is precipitated from the filtered solution by the careful addition of a solution of chloride of lime to the perfectly neutral, hot and not too dilute filtrate. If too much chloride of lime is added the precipitate becomes nickeliferous, and this must be carefully avoided. The nickel is next precipitated, either by calcium carbonate, milk of lime, or soda. The nickel hydrate is filtered, dried, heated with sodium carbonate, to decompose any calcium sulphate that may be present, washed with acidulated water, and finally dried and reduced by carbonaceous materials to the metallic state.

and nickel.

"This process being dependent on the fractional precipitation with the same precipitants of the several metals present in the ore or metallurgical product under treatment, is frequently subject to slight alterations of procedure, and the following is a description of the process as carried out at a works in the United Kingdom.

A special process described.

WET PROCESS FOR EXTRACTING NICKEL AND COBALT.



A. Calcined ores or speise of nickel and cobalt.

B. Granite jar for containing H Cl. Steam passed in.

C. Precipitation of iron and arsenic by milk of lime after peroxidizing the ferrous oxide by $CaOCl_2$. Steam passed in.

D. Filter.

E. Solution. Pumped up to F.

F. Precipitation of copper sulphide by sulphuretted hydrogen.

G. Filter.

H. Ni and Co solution. Pumped up to J.

J. Solution carefully mixed with metallic iron, chalk and chloride of lime. Steam passed in. Sulphuretted hydrogen evolved.

K. Filter.

L. Stock tank. Solution pumped up to M.

M. Dividing tank. Heated to 40°. Co precipitated by $CaOCl_2$.

N. Filter.

Residue —Co_2O_3 to market.

O. Nickel. ppt. by milk of lime.

—Ppt. reduced to metallic nickel.

Wet process for extracting nickel and cobalt.

"About 3 cwt of fine ore or speise A that has been thoroughly roasted is charged with hydrochloric acid in granite jars, into which steam is passed. The mass is kept boiling for twelve hours. It is allowed to settle and run off into tubs C. Steam is conducted into the tubs, and when the liquid begins to boil bleaching powder (chloride of lime) is added to peroxidize the iron, and the mass is allowed to boil for about three hours. The arsenic and iron come down together. If no iron be present in the solution some must be added. The liquid is then run off through filters D, to underground tanks E, whence it is pumped to tanks F, in which the mass is treated with sulphuretted hydrogen. Adjoining these tanks, of which there are six, there are also three lead retorts, in which sulphuretted hydrogen is produced. In these tanks the copper is precipitated and the nickel and cobalt solution is strained through filters G, and drains into a second underground tank H. It is then pumped into a tank J, and there successively mixed with iron, chalk, chloride of lime, and water from tubs placed above the tank, with a view to precipitate, first, any copper that may have passed into solution during filtration, and then the iron which has taken the place of the copper. The charge is first boiled by the aid of steam pipes so as to expel the sulphuretted hydrogen. It is then run off to a tank L for stock. It is next pumped up into a dividing tank M, and heated with chloride of lime, the cobalt being precipitated as oxide at a temperature of 40°. The solution containing nickel is allowed to run off into another tank o, in which milk of lime is added, and the nickel precipitated as hydrated oxide. The liquid is allowed to run off as waste. The oxides are pumped into presses, and the water is drained off. The nickel oxide is dried on the roof of a muffle, heated and crushed. It is then mixed with charcoal and heated in a crucible in a reducing furnace for eight or twelve hours. A rough powder is obtained and in this form the metal is sold, or the nickel oxide is mixed into a paste with flour and water, which is heated and cut into cubes. These cubes are placed in crucibles with charcoal and heated to a temperature above the melting power of copper. The nickel oxide is reduced by the charcoal and by the carbonized flour. The metal does not melt, but preserves the form of cubes. The cobalt oxide is removed from the dividing tanks to stone jars and treated by a process similar to that described so as to remove the last trace of nickel. The cobalt is finally sent to the market in the form of oxide."[3]

Price of nickel maintained by cost of refining process.

It will be readily understood from the complexity of this process that it must be an expensive one; hence the high price which fine nickel has maintained. But there are various methods of the wet process, some of which are of recent invention, and possibly the cost of production may be somewhat reduced by them. One of these is soon to be tested at the village of Port Colborne at the head of the Welland canal, where advantage will be taken of the supply of natural gas there for fuel. Gypsum supplied from mines in the adjoining county of Haldimand is to be largely used under this method, and hope is entertained that the sulphuric acid obtained as a bye-product will very considerably reduce the cost of producing the refined metal. The results of this method are awaited with much interest.

A new wet process to be tested at Port Colborne, in which gypsum will be utilized.

Dry processes.

As to dry processes, including reduction of oxide by carbon in furnaces or crucibles and concentration in sulphide or arsenide and subsequent smelting in reverberatory or blast furnaces, there does not yet appear to be absolute certainty that such methods can be successfully and economically applied to the treatment of nickel ores through all stages to the refined metal; but the metallurgy of nickel is so recent a subject of investigation and experiment that no one will be so bold as to say that the last word has been spoken upon it.[4]

PRODUCTION AND PRICE.

Growth of the industry and fall in price of the metal.

Seventeen years ago nickel in the United States was worth $2.60 per pound. Twelve years ago it had fallen to $1.10, the New Caledonia mines having been discovered and opened in the interval. At that time the world's yearly production of nickel was about 1,000 tons. Last year the price fell in the United States to fifty cents per pound, and in Great Britain to 42 cents. But the world's production had then increased to 6,000 tons, of which

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[3] An Introduction to the Study of Metallurgy pp. 268-71.

[4] While this Report is going through the press an interesting correspondence is being carried on upon this subject in the Engineering and Mining Journal of New York, between Robert M. Thompson, President of the Orford Copper Company, and Dr. Stephen H. Emmens, President of the Emmens Metal Company. The following letter from Mr. Thompson is printed in the Journal of June 17th: "In your issue of June 3rd I note a very interesting letter from Professor Emmens headed 'Nickel Winning,' in which he says, 'No wholly dry process hitherto employed is capable of separating cobalt, or even (to a thoroughly satisfactory extent) copper, arsenic and manganese from nickel;' and referring to the Canadian pyrrhotite ores, 'The metal produced by dry methods from such a raw material is not fitted for fine uses.' In reply let me say that the following assays were made by the same chemist for nickel: Wharton's grain nickel, 99.39 per cent.; Martino's disc nickel (finest foreign nickel), 99.06 per cent.: Orford nickel, produced by exclusively dry process from Canadian pyrrhotite ores, 99.23 per cent. As to the quality of the Orford nickel, while I do not claim it is yet as perfect as we hope it soon will be, yet one of the largest consumers of nickel in the country writes me: 'In some respects your nickel is superior to any we have ever used. The metal is very white and remarkably soft and ductile, both of which points are of the greatest value.' Knowing Professor Emmens' interest in the metallurgy of nickel, I am sure he will be pleased to see what progress has been made in the dry process for treating this metal." But notwithstanding this assurance, Dr. Emmens does not appear to be wholly satisfied as to the merits of the process.

Ontario produced about one-third and New Caledonia two-thirds. Should increase continue at the same rate for the next ten or twelve years we shall doubtless see great activity in mining, smelting and treating operations in this Province, especially should improvement continue to be made in processes, and prices fall as a consequence. It will not be surprising if in less than ten years prices have fallen to 25, or 20, or even 15 cents per pound, and in that event a large increase may be expected to take place in consumption. Assuming that no larger or better deposits of the ore are discovered elsewhere, what are the prospects of nickel mining in this Province in the event of a growing demand? The answer to this question may be found possibly in the words of the last United States Census Report on Mineral Industries. Referring to nickel and cobalt mining in that country in 1889, the writer says the great feature of the year was "the diversion of all attention in nickel mining to the nickel-bearing copper ores of the Sudbury region in Canada." And he goes on to say: "The course of development showed conclusively that nickel can be produced there for a less cost than anywhere else in the world, so far as the present capacity of the known mines permit of an opinion." And referring to the New Caledonia mines farther on the same writer says: "At present the mines are less influential than those of Canada, for although the ores are fully as rich, labor is not so good, and for imported laborers the climate is bad. The ores are found in v-shaped pockets in serpentine, which is found over two-thirds of the island. Many of the pockets are large, but narrow with the depth. The cost of mining is considerable, and the transportation facilities to the sea coast are poor. It is not probable that the mines can compete successfully with the Canadian."[5]

Prospects of nickel mining in Ontario.

The rivalry of New Caledonia.

Whether the working of manganiferous iron ores on that island containing cobalt and nickel will or will not change the condition in its favor cannot yet be foreseen, but it is hardly probable. Nearness to market, abundance of ore, and a supply of competent free labor and facilities for quick transportation are advantages which the Sudbury district is likely to continue to possess over its New Caledonia rival for all time.

THE FUTURE OF NICKEL.

The future of the nickel industry depends on the distinctive utilities of the metal, on the quantity and cost at which it can be supplied to consumers, and in a less degree on the quality of appearance. Twenty years ago pure nickel was not known in the arts; up to that time it was nothing more than an alloy with other metals combined with it in the ores, from which at best it was only imperfectly separated; and it was not indeed until after the pure metal began to be produced—the first examples of which were shown by Joseph Wharton at the Philadelphia Exposition of 1876—that its most valuable uses began to be found out. Some of these will be mentioned here as evidence of the growth of the nickel trade, and as an indication of the lines upon which it is likely to develop.

Finding out valuable uses of the metal.

The experiments conducted four years ago by James Riley of the Glasgow Steel Works with alloys of nickel and steel made a profound impression when the results were published; and although this may not prove in time to be the most valuable or useful of all the applications of the metal, it is the one which at present most strongly arrests attention in America. The explanation of this fact is found in the tests which, during the last three years, have been carried on by the Navy Department of the United States to determine the sort of material for armor best suited for the battle ships under orders of construction by the Government of that country. Mr. Riley's paper, read at the May meeting of the Iron and Steel Institute in 1889, contained no more than a speculative suggestion of the application of nickel steel to the armor plating of ships, but Secretary Tracy of the United States Navy

Riley's experiments.

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[5] Report on Mineral Industries in the United States at the eleventh Census, 1890, pp. 269-71.

Armor plate trials in the United States.

Department regarded the promise held out as "too great to be ignored by a Government requiring 20,000 tons of armor for its new fleet." Accordingly he began a series of trials to prove the suitability of nickel steel for the purpose in view, and not only so but to settle the question of the best armor plate in relation to the best ordnance—the strongest defence to match the most powerful attack. The following extract from the Secretary's report for 1891 shows the progress of the trials up to the close of that year :

ARMOR PLATE TRIALS IN THE UNITED STATES.

Tracy.

Report of comparative tests in 1891.

"The experiments made last year at Annapolis, described in the annual report for 1890, consisted of a test of the two principal foreign types of armor, the English compound plate and the French all steel plate, and an entirely new plate also made in France upon the special order of the department, of nickel steel. The result of the trial showed that the compound plate was decidedly inferior, and that as between nickel steel and all steel the former had distinct and positive advantages, the all steel plate being broken into four pieces, while the nickel plate remained absolutely uncracked.

Nickel steel plate adopted by the Navy Department.

"A series of tests made during the following spring and summer confirmed the conclusions formed at the Annapolis trial as to the superiority of nickel steel, and the department accordingly decided to adopt it, and made arrangements with the contractors looking to that end.

Trial of home made plate.

"It remained however to give a thorough trial to the first armor of domestic manufacture before beginning to place it upon the vessels, and for this purpose it was decided to order typical plates which should be made the subject of an experimental test. This trial was to ascertain two points : first, whether our domestic manufacturers could produce an armor that would stand competition with the material manufactured abroad ; and, second, which of the various modes of treatment suggested would give the best results. In reference to the latter point the questions to be considered were the relative merits of rolling and forging in the manufacture, and the effect of a new method of treatment, named from its inventor the Harvey process, designed to harden the surface of the plate while retaining the toughness of its body.

Relative merits of rolled and forged plate.

"Of the six plates tried three were furnished by the Bethlehem Iron Co., and three by Carnegie, Phipps & Co.

"In these trials, which took place at Indian Head on October 31 and November 14, the plates were subjected to tests more severe than had been applied at any foreign Government trials. Four shots were fired at each plate from a 6-inch gun with an impact velocity of 2,075 feet per second, and an energy of 2,988 foot tons, using the Holtzer projectile of 100 pounds. One shot was then fired at the centre of each plate from an 8 inch gun, with an impact energy of 4,988 foot tons, using Firminy and Carpenter projectiles of 210 and 250 pounds weight respectively. The plates were placed normal to the line of fire.

The results.

"The results of the trial were in the highest degree satisfactory. Each of the six plates manufactured in this country was superior to the English compound plate, while the nickel harveyed plate and the high carbon nickel plate were superior to all the foreign plates of the Annapolis trial. They may therefore be pronounced in advance of the best armor hitherto manufactured in Europe.

Superiority of the nickel plate demonstrated.

"Further light was thrown upon the question of the relative merits of all steel and nickel steel armor, and any doubt which may have remained upon that subject was finally set at rest. Of the three plates made by Bethlehem, two were of nickel steel, one treated by the Harvey process, the other not, and the third was of all steel, harveyed. Both the nickel plates proved to be far superior to the all steel harveyed plate, notwithstanding the advantages which it may have derived from the special treatment; and both proved superior to the French all steel plate tried at Annapolis.

Tracy.

Equality of rolled and forged plates.

" A third nickel plate, manufactured by Carnegie under the rolling process, also showed a marked superiority over the all steel plate of this year, and both it and the corresponding Bethlehem plate manufactured under the hammer showed a capacity of resistance to perforation fully ten per cent. greater than that of the French all steel plate. In this respect the results furnished by the two American plates manufactured by the different processes (forging and rolling) proved to be remarkably uniform, the 6-inch shots that were fired at them differing in penetration but an inappreciable amount.

Lessons of the trial

"The trial thus definitely establishes the fact that armor of excellent quality may be produced by the rolling process, and that forging by means of the hammer, the greatest source hitherto of expense in manufacture, is no longer to be regarded as an absolute necessity. The importance of this fact can hardly be over-estimated, for it raises a probability that within a year or two the armor-producing capacity of the United States may be quadrupled in case of necessity, and that if we had 10,000 tons to let and could give 18 months from date of contract to commence delivery, the cost of manufacture would be reduced from 25 to 33 per cent., while the work hitherto confined to two firms would be thrown open to a large number of competitors "[6]

Report of trials in 1892.

In his report for 1892 Secretary Tracy reviews the steps which had been taken by his department for the development of armor, and after special reference to the trials at Indian Head in October and November, 1891, he goes on to say :

Tracy.

Improved methods in the Harvey process.

" As a result of this trial improved methods were introduced in the Harvey process and further tests were ordered of new plates. The first of these tests took place July 26, 1892, at Indian Head. The plate used was a 10½-inch plate of nickel steel made by the Bethlehem Iron Company, the plate having first been forged to 12½ inches and then harveyed, and finally reforged to its former dimensions. In the two previous trials the corner shots had been fired from the 6-inch gun, and the 8-inch had been used only upon the centre of the plate. In this trial the 8-inch was used for all of the shots. The result was that three of the projectiles were broken up upon the surface of the plate, while the two right hand shells penetrated to a depth of 13 inches. It was evident that there was a want of uniformity in the hardness of the surface and that some special cause must have softened the right hand side of the plate. Upon investigation it became apparent that this was due to the process of reforging, resulting in a lower temperature and consequently reduced carbonization upon this side of the plate. Notwithstanding the penetration of the two right hand shots, the result by which the plate had remained free from cracks after receiving five blows from 8-inch projectiles was an extraordinary confirmation of the expectations that had been formed as to the possibilities of nickel steel treated as described.

A comparative failure due to imperfect forging.

A final trial crowns the efforts of four years with highest success.

" It remained for a final trial to demonstrate the wisdom of the steps which had been taken and to crown the efforts of nearly four years with the highest degree of success.

" This trial took place at the proving ground of the Bethlehem Iron Company, July 30, 1892. The plate was of nickel steel, harveyed, of the same thickness (10½ inches) as that of the previous trial, but unlike its predecessor it had been forged to its final thickness before the Harvey process was applied. As in the previous trial the 8 inch gun was alone used. Five Holtzer forged steel shells, weighing 250 pounds each, with a striking velocity of 1,700 feet per second, and each with an energy of 5,000 tons to the square foot, were fired at the plate at a distance of 30 yards.

" Never before these trials had any armor plate in the world been subjected to such a test as was represented by these five blows of a total energy of 25,000-foot tons.

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[6] Report of the Secretary of the Navy for the year 1891, pp. 11-13.

Tracy.

The projectiles smashed upon the surface of the plate.

"The result may be told in a word. All five of the projectiles were smashed upon the surface of the plate. The plate showed no signs of injury further than the opening of a slight temper crack four inches in length from one edge, and a wale less than one inch in thickness on the back of the plate opposite each point of impact. The striking ends of the projectiles appear to have been splashed on the face of the plate, filling the slight indentation made by the blow with new material which became welded to the substance of the plate itself and left it as before a flush surface. The remainder of the projectiles could only be found in the shape of innumerable scattered fragments.

A result never before equalled or approached.

"The result above described has never been equalled or even approached before by anyarmor plate, American or foreign. It has demonstrated that the United States, in the reconstruction of its new navy, which ten years ago had no existence even on paper, is enabled to place upon each and all of its armored vessel a material the like of which the world up to this time has not seen; and that while vast sums have been spent in plating the sides of foreign men-of-war with an inferior material, this country will employ for the purpose an armor which is not only far more efficient, but which represents unquestionably, having reference to the dimensions of plates thus far tested, the highest development of modern science, and a development reached by its own independent efforts."[7]

A large purchase of Ontario nickel.

As early in the course of these trials as September, 1890, the Secretary of the Navy was so well convinced of the superiority of the nickel steel plate that he asked and obtained from Congress an appropriation of $1,000,000 for the purchase of nickel matte. At this time an apprehension existed in the minds of United States authorities that the world might not be able to produce enough nickel for their wants, and they feared that prices would take a bound upward. They accordingly purchased from the Canadian Copper Company 4,536 tons of matte, containing about 900 tons of nickel. "The terms of thecontract provided that the material should be delivered on board cars at Sudbury, Ontario, for transportation to such points as might be designated. Deliveries were to begin within three days from the date of the contract, and final deliveries were to be made within one month thereafter. Provision was made by means of competent assayers for ascertaining the quantities of nickel and copper contained in the matte, and that no carload should be shipped in which there was less than an average of 15 per cent. of nickel."[8] The payments to the Canadian Copper Company for matte amounted to $321,321.86, while freight cost $31,134.88, duty on the copper contents $9,547.40, and refining by the Orford Copper Company (in part estimated) $97,582.30, making a total expenditure under the appropriation of $459,586.44. "Of the nickel oxide produced by the Orford Company, by whom the refining is done, we are now using 40 per cent., while 60 per cent. is sold in Europe. Our material, after the payment of all charges, including the price of the matte and of the subsequent reduction, costs us 24 cents a pound, while that of other consumers costs them at least 38 cents."[9]

Nickel required for an ordinary war vessel.

But this is the cost of the oxide. The quantity of armor plate required for an ordinary war vessel such as the United States is constructing is about 3,200 tons, and as the contract with the makers calls for only 3¼ per cent. of nickel in the plate, the quantity of nickel used for one vessel is only about 104 tons, or say 135 tons of nickel oxide. Obviously therefore there is a modest limit to the quantity of nickel required for the manufacture of armor plate for the United States Navy, unless the Government of that peaceful republic should seek to emulate the naval greatness of all the European powers, which is as improbable as that she should follow their example in the creation and maintenance of a standing army.

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[7] Report of the Secretary of the Navy for the year 1892, pp. 17-19.

[8] Secretary's Report for 1892, p. 21. The first contract appears to have been for 536 tons, and the second, under date of June 15, 1891, for 4,000 tons.

[9] Secretary's Report for 1892, p. 21.

NICKEL STEEL FOR HEAVY ORDNANCE.

Experiments with nickel steel for great guns.

But there is some likelihood of nickel steel being used in the manufacture of heavy ordnance as well as for armor plate, and at the present time experiments are being conducted to test its suitability for that purpose. The following extract from a lecture delivered before the Franklin Institute of Philadelphia last January by Mr. W. H. Jaques, Ordnance Engineer, will show what is being attempted as well as what has been done in this direction :

Jaques.

"The increasing use of nickel in steel suggests a few words concerning this element, particularly as it is about to make its debut in a large calibre service gun (a thirty-five calibre eight inch B. L. R), the forgings for which have been made by the Bethlehem Iron Company.

Confirmation of Riley's conclusions.

"In this connection it is most seriously to be regretted that circumstances of a discouraging character should have intervened to prevent Mr. Riley's continuing the excellent metallurgical work he so happily and ably commenced in connection with the alloys of nickel and steel, particularly since the publication of his lecture to the Iron and Steel Institute, May 4, 1889, so many of his views have been proved by further experience and practice.

"Bethlehem's part in this work is so well known by the practical results she has obtained, the gun forgings and other products supplied, and the superior resistance of her armor, that I need make no detailed statement here of our accomplishments. Further, they have already been referred to by the chiefs of the Bureaus of Steam Engineering and Ordnance in their last annual reports.

"As you will no doubt recall, Riley, Dick and Packer commenced their experiments with samples of French crucible nickel steel, containing three per cent., five per cent. and twenty-five per cent. of nickel ; were subsequently assured by personal investigation that the desired products could be obtained with certainty, not only in the crucible, but with perfect control in the open hearth, and that nearly all the nickel would be found in the steel. Riley, in the lecture referred to, described the action of the steel in the mould, its appearance, value of scrap, and the care and temperatures required to work it. He made a sufficient number of tests to show the marked increase of tensile strength and elastic limit produced by certain increments of nickel without impairing the elongation or contraction of area to any noticeable extent. He pointed out the effects of a variation of the proportions of carbon and manganese with the same percentage of nickel, the point where the increment of nickel changed its hardening influence to one of softening ductilizing, its neutralizing effect upon carbon, the difficulties of machining, and crowned his report by giving due credit to the patentee, French steel makers, his assistants and the authorities.

"Together with other conclusions he said : 'I am glad to be able to state that before the region of extreme difficulty of machining is reached, we have qualities of nickel steel available which will be of the utmost value for a very large number of purposes.'

"Comparing ordinary steel with nickel steel, he adds : 'I think there will be no hesitation in deciding that there will be a very great advantage gained by the use of the latter—advantage either in reduction of scantling or in increased strength and ductility. In the very important matter of corrodibility, it is with the greatest satisfaction I can state that the steels rich in nickel are practicably non-corrodible, and that those poor in nickel are much better than other steels in this respect. Some samples of the richer nickel steels which have been lying exposed to the atmosphere for several weeks will show an untarnished fracture.'

"These experiments to test the non-corrodible qualities of the various percentages of nickel steel, it will be remembered, were made in connection with Abel's corrosive liquid and hydrochloric acid water.

"I have cited Riley's conclusions to show how accurately they have been verified by the results since obtained, which give abundant testimony of the care and faithfulness with which his experiments were made.

"Mr. Hall of Sheffield claims to have made the first nickel steel gun, which instrument is reported to have burst at the first round, the rupture being due to the absence of suitable transverse strength. Whether this was due to the poor steel, poor construction, or the presence of nickel, was not stated.

Krupp's comparative tests.

"Many other nickel steel guns have been experimented with, but Krupp's comparative tests of two three and a half inch field guns, one made of ordinary Krupp steel and the other of nickel steel, appear to be the first trials of much importance that have been given publicity.

"Each gun was loaded with shell containing 170 grammes of picric acid, the centre of the shell in each case being 300 millimetres from the muzzle.

"When the shells were exploded the crucible steel gun burst into many pieces, while the nickel steel gun remained entire, showing an increase of the bore of 7.4 millimetres at the site of the projectile, but no cracks any where.

"The trial was continued with another shell containing 180 grammes of picric acid. Its explosion caused an enlargement of 9 50 millimetres and a longitudinal crack 80 millimetres long. No particle of metal was detached from the gun."[10]

In connection with the foregoing extract from Lieutenant Jaques' lecture the following account from the London Iron of further experiments by Herr Krupp are worthy of notice (unless indeed it is only a different account of the same experiments):

"A new nickel steel, the secret of the manufacture of which has been secured by Herr Krupp of Essen, has been experimented with at Meppen. Two 3.4 inch shells, each containing 6 oz. of picric acid were placed, one in a gun of ordinary Krupp steel, and the other in a gun of the new nickel steel, at a distance of 12 inches from the muzzle. Upon the shells being exploded, the muzzle of the gun of ordinary steel was blown into a number of pieces, but the only effect produced upon the nickel steel gun was a local enlargement of the bore to the extent of a quarter of an inch. In the next experiment a 3.7 inch shell, containing 6.3 oz. of picric acid, was burst in a nickel steel gun at a point 19.5 inches from the bottom of the bore. The results were an enlargement to the extent of one-third of an inch and a fissure of three inches in length. Trials of plates of this nickel steel have also been made and are stated to have given satisfaction."[11]

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[10] Present Development of Heavy Ordnance in the United States, by W. H. Jaques, p.p. 25-27. Lieutenant Jaques (who has served 21 years in the U. S. Navy) is the author of a valuable essay on "The Establishment of Steel Gun Factories in the United States," published in the Proceedings of the United States Naval Institute in 1884 (pp. 527-909). It was largely upon his recommendations that the Government of the United States undertook to promote the manufacture of armor plate and ordnance at home instead of depending for supplies upon European makers, and when the Bethlehem Iron Company six years ago resolved to undertake the manufacture of guns, shafting and armor plates, the position of Ordnance Engineer was offered to Lt. Jaques. The object of the Company was, as stated by Mr. Jaques in an article descriptive of the works published in the Proceedings of the Naval Institute "to erect a plant long needed in the United States to make the country independent in the possession of the means of supplying the nation with the most powerful guns and of equipping her ships with the most efficient shafting and armor." To this end a number of new and large buildings have been erected on the Company's grounds along the Lehigh river, which have been furnished with the best of modern machinery, and new buildings are still going up which, when completed, will no doubt make the Bethlehem works the largest in America. Upon a visit to Bethlehem last October I was shown through the various departments by Mr. Jaques, and a note of the armor plate and ordnance branch of the works may be fittingly made here. Four Siemens open-hearth furnaces are employed in the production of nickel steel, two of which have a capacity of 40 tons each per day of twelve hours, one of 20 tons and one of 10 tons. The process of alloying the metals is claimed to be a company secret, and to give better results than is obtained elsewhere. During my visit the 20-ton and one of the 40-ton furnaces were tapped and run into a mould, casting an ingot of 60 tons nickel steel. This contained 3¼ per cent. nickel, which is the Government requirement for armor plate, or a total of very nearly two tons (1.95). For a portion of the time the Siemens furnaces are employed in making all steel, the ingots of which are compressed into cylindrical shape by hydraulic power. Two of these, still warm from the press, were lying on cars ready to be taken to the forging shop. They looked like two great saw-logs, being 4 feet 6 inches in diameter and 15 feet in length. The ingots are forged under powerful steam hammers into any required shape, some for armor plates, some for guns and gun casings, and some for shafts, cranks, etc. The armor plates are heated in low furnaces, forged flat, requiring frequent reheating before the process is completed, and afterwards shaped by hydraulic power and tooled by machinery. After being finished in this way they are fitted together on platforms so that when sent to the shipyards each piece is ready to be put into the place designed for it without further machining or shaping of any kind. The specifications are furnished by the Navy Department, and hardly any two plates of the same ship or of any two ships are alike. Many of the plates weigh 30 tons and upwards. The long guns are heated in an upright furnace, some of the forgings being 25 to 38 feet in length, and weighing 25 to 45 tons. They are forged under a steam hammer weighing 125 tons.

Material for the construction of shafts, cranks, etc.

It is not improbable therefore that nickel steel will soon be utilized in the making of heavy ordnance as well as armor plate ; and the frequent accidents which have recently occurred in the breaking of shafts of the great ocean liners will doubtless suggest the manufacture of shafts, cranks and indeed all important parts of the machinery of passenger ships as well as battle ships of nickel steel.

ARMOR PLATE IN EUROPE.

Experiments in Great Britain.

We know much less of the purposes to which nickel steel is applied in Europe, for the reason that the Governments of that continent are much more secretive in the trials they are carrying on than is the Government of the United States. A year ago the British Secretary for the Admiralty informed Parliament that nickel steel had been experimented with largely, that extensive orders had been placed for nickel steel armor forming the secondary defence of battle ships now in course of construction, and that several are fitted with this kind of armor which has been proved sensibly superior to ordinary steel when used in thicknesses of three or four inches. But the officials of the British Admiralty have been much slower to acknowledge the superiority of nickel steel for armor plate purposes than were their brethren in the United States, although the first suggestion of the usefulness of the alloy for this purpose was made by James Riley. But the astonishing results obtained in the United States last year at Indian Head and at the Bethlehem proving grounds could not any longer be ignored, and on the 1st of November a test was made at Portsmouth on board the target vessel Nettle. Up to this date tests in Great Britain had been confined to all steel and compound armor plates manufactured by English makers; but in this instance the experiment possessed a two-fold novelty, the plate submitted to the ordeal being of a nature new to Europe and having been manufactured in accordance with an American patent. The London Engineer furnished this account of the trial :

A surprising test on board a target vessel.

The Engineer's account of the test.

"The plate was made of high carbon nickel steel harveyized, or harveyed, by carbonizing the face and hardening it with jets of water. We may state at once that we are not in a position to report trials of this class from independent observation. The series of trials on board the Nettle are carried out by Admiralty officers, and are in all respects trustworthy ; but in the interest of makers who in various stages of these trials might submit plates of an entirely experimental character, no officer or other official is allowed to treat the results as public property. In point of fact they are regarded as confidential unless the manufacturers wish to publish them themselves. There is we think no reason to find fault with this system. Certainly manufacturers have been thereby encouraged to make experiments which they might otherwise shrink from attempting, and although doubtless the effect must be that the public hear only of successful results they hear of them on trustworthy authority, and a very fair idea is obtained of all such work as is sufficiently good to be admitted into the service ; and this is what mainly concerns the public, and when the photographs officially taken are published little is left to be desired as to completeness of information.

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[11] Iron, February 24th, 1893.

"The trial in question is an important one. Photographs of the best Harvey plates tested in America have been printed by us. We pointed out then that the shape taken by the remarkable result achieved was the holding together of the plate under the wedging strain of five 8-inch projectile heads, which penetrated to a considerable depth. In fact the hard face due to the Harvey process caused the projectiles to break, and though the heads had impressed energy enough on the plate to penetrate to a considerable depth the plate, as we suggested, probably thanks in a great measure to the nickel in its composition, held wonderfully well together. Tresidder's plate, which was naturally compared with it, performed a slightly different feat. It broke up 6-inch projectiles in its face with very insignificant penetration. Thus the projectiles were more completely defeated, but they were much smaller. The Tresidder plate, be it observed, was in consequence of the complete defeat of the projectiles not submitted to the wedging strain which fell on the Harvey plates, and there is no evidence as to how it would have behaved under it.

"Clearly the link required from Harvey's point of view was to show that the plate face was capable of defeating the lighter 6-inch projectiles with as little penetration as in the Tresidder plate. This was needed, for the last Harvey plate attacked by 6-inch shot had certainly allowed their points in two cases to penetrate deeply ; one side of the plate was in fact softer than the other. There was an explanation for this, but no explanation is as good as a successful performance. The success at Portsmouth therefore is, we venture to think, just what we want at the present moment, and we are endeavoring to obtain permission to publish the photographs, which as yet we have not obtained.

"A competitive trial at Ochta, near St. Petersburg, is expected to take place shortly, when the Harvey, Tresidder, St. Chamond and Schneider plates will be tested in a strictly comparative way by 6-inch forged steel Holtzer projectiles, fired with about 2,000 feet velocity. The Nettle trials consisted of an attack of three 6-inch Holtzer and two Palliser chilled iron shot, striking at a velocity of about 1,976 feet per second. The Palliser projectiles are expected to break up as a matter of course with comparatively slight effect. It is only latterly that the Holtzer shot have been similarly defeated. In the present instance they have, we understand, broken into small fragments with but little penetration."[12]

Another account was published in Iron, and this paper, after citing the statements of the U. S. Secretary of the Navy and the Chief of the Bureau of Ordnance on the trials conducted under their direction, went on to say :

Iron's account of he test.

"However much these positive statements might be discounted, it was impossible for the British Admiralty, considering the official authority on which they were published, to discredit them entirely. It consequently determined to submit them to a practical test, and with this object in view it entered into negotiations with the agents of the Harvey Steel Company of New York. Eventually Messrs. Vickers & Co. of Sheffield were commissioned by the Government to manufacture a nickel steel plate and to treat it according to the Harvey process by which extraordinary hardness is communicated to the surface, together with a proportionate amount of toughness, so that the increased brittleness which commonly attends the hardening of steel is prevented. This was the plate that was tested on board the Nettle. The experiment was in no sense a manufacturer's, but an Admiralty test. It is the only trial of a harveyized plate which has yet taken place in Europe, for although a similar plate has been manufactured by the same makers for the Russian Government, it will not be fired at until next week.

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[12] The Engineer, London (England), November 4, 1892.

"The trial, which was conducted by Captain Hugo Pearson of the Excellent, was witnessed by W. H. White, C.B., Director of Naval Construction, Admiral Colomb, General Geary, R.A., Captains Jenkins and McKechnie, of the Ordnance Committee, Colonel W. W. Barlow, late of Woolwich Arsenal, and other officials. The Harvey Steel Company was represented by Mr. Edwin W. Fox and Mr. Joseph H. Dickinson of New York, and the manufacturers by Messrs. Albert and Thomas Vickers. The plate measured 6 feet by 8 feet, with a thickness of 10½ inches. Its dimensions were consequently the same as those of other sample plates tested on board the Nettle, and though the representatives of the steel company expressed a wish that it might be attacked by a gun of larger calibre and greater ballistic properties than the one usually employed, the test for purposes of comparison was of the ordinary character consistent with Admiralty conditions. This consisted of discharging five rounds at the target from the six-inch breech loader. The charge was 48 lb. of E.X.E. powder, the weight of projectile 100 lb., and the muzzle velocity 1,975 feet per second. The rounds were fired in the following order: (1) Holtzer steel shell at bottom right-hand corner; (2) Holtzer at upper left-hand corner; (3) Palliser shell at upper right-hand corner; (4) Palliser at lower left-hand corner; (5) Holtzer in the centre.

The result an astonishing success.

"The result of the firing was an astonishing success, and completely verified the accuracy of the reports received from America with reference to the merits of the Harvey hardening process. Contrary to ordinary experience the Palliser projectiles appeared to do as much execution as the French shells, for although they splashed upon the plate on impact they made indents of about 1½ inch in depth. The Holtzers on the other hand appeared to weld their points into the target before bursting into a thousand incandescent fragments. Every one was completely pulverized. The most remarkable feature of the trial however was the fact that the plate withstood its punishment so well that not a single crack was produced—a quite unprecedented circumstance in armourplate experiments. Further trials with thinner plates are to be prosecuted at Portsmouth, and should these prove correspondingly invulnerable many of our obsolete armorclads might easily be brought up to date by superseding their thin iron protection by the new armor of equal thickness and weight, but of greatly superior impenetrability."[13]

It is not known what decision if any has been reached by the British Admiralty authorities with respect to future construction, following this trial of armor plate on the Nettle, but it is not likely that the value of the lesson will be wholly lost. The Engineer in commenting upon the First Lord of the Admiralty's memorandum on the naval estimates for 1893-4 says:

Possible adoption of the harveyized plate by Great Britain.

"Doubtless advantage will be taken of the increased resisting power to penetration afforded by the harveyized nickel steel plates; and, as a diminished thickness of armor can now be carried, it will probably be distributed over a greater area. We have slowly but surely been emancipating ourselves from that curious predilection for a small patch of enormously thick armor, of which the Inflexible was the earliest example.[14]

The cost of nickel steel plate.

It is not likely that a pre-eminently naval power like Great Britain, which is now expending over $70,000,000 a year to maintain a navy adequate to her requirements, and building battle ships at a cost of $3,000,000 to $4,000,000 each for those of the first rank, will long be content to use any other than the best of material. Nickel steel plate will cost more than all steel plate, perhaps much more; but it will in part make up the extra cost in greater lightness and increased efficiency, and in the construction of battle ships efficiency is the point of first consideration. Referring to the cost of nickel steel armor plate to the United States Government the Engineering News of New York says:

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[13] Iron, London (England), November 4, 1892.

[14] Engineer, March 10th, 1893, p. 211.

"Prices obtained for armor plates by the Carnegie and Bethlehem steel companies, who are the only manufacturers in the country, may well excite the envy of steel-makers who hunt for customers for best structural steel at prices under $40 per ton. Bids were opened on February 5th at the Navy Department for about 7,000 tons of nickel steel armor plate. The prices bid by the two firms ranged from $520 to $885 per ton for the different sizes and kinds of plate specified. About $56 per ton extra is asked for treating the plates by the Harvey process. Making a very liberal estimate for the cost of manufacture, it looks as if the profits on this order alone ought to go a long way toward repaying both the companies for their original expenditure on their armor-making plant. It is of interest to notice also that at an average price of $600 per ton the armor for the new line battle ship Massachusetts will cost about $1,225,000. The total cost of the vessel was estimated at $3,020,000."

The total quantity of armor plate required in the construction of this ship is 2,042 tons, the nickel contents of which would be at $3\frac{1}{4}$ per cent. (if gross tons are meant) not quite 150,000 pounds. Assuming the price to be 50 cents per pound, the cost of nickel contents in the plate will not exceed $75,000 (or $46,750 at the cost of nickel oxide). Unless then the cost of making nickel steel is vastly greater than of other alloys the question of cost of nickel steel plate will not long stand in the way of its adoption by Governments which are persuaded of its superiority. Nor is it likely that the Carnegie and Bethlehem works will long continue to enjoy a monopoly of supplying this plate to the Government at $600 per ton.

Tests in Russia.

The tests conducted by the Russian officials at Ochta were made upon one French and two English steel plates and a Vickers-harveyed nickel steel plate, and in commenting upon this trial the London Engineer reports the latter "to have altogether beaten its competitors."[15]

Effect of a general adoption of nickel steel armor plate on the production of nickel.

With all this evidence to demonstrate the value of nickel as an alloy with steel in the construction of war ships, the chances would appear strongly to favor its being so used by the navy building powers. Yet the demand for the metal would not be enormously increased if all the navies were to be reconstructed with nickel steel for armor plate; it would not be necessary perhaps to more than double the present production.

OTHER USES FOR NICKEL.

Whence then is an increased demand for nickel likely to arise? What other purposes give greater promise of consumption than the making of armor plate and ordnance? A few of these may be indicated.

Material for boilers, engines and locomotives.

As an alloy of steel the greatest use of nickel may be found in the making of boilers, engines and locomotives and structural material generally, where it is of vast importance to combine lightness and strength. In a large Atlantic liner for instance the plates of the boilers are one and a half inches thick, and enormous force is required to bend and rivet them, in which operation the plate is likely to be weakened by fracture, the lines of which are not always visible. If made of nickel steel alloy the plate would require to be little more than half the thickness, and while the boiler would be more easily and securely made, it would be but one half the weight—a very important item where there are twelve or thirteen huge boilers in the hold of one ship. Its strength would be as great, and it would be less liable to corrode. It would cost a little more, but its life would be lengthened.[16]

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[15] The Engineer, March 24, 1893, p. 256.

In the making of parts of locomotives and steam engines, as well as in the manufacture of cranks and shafting, nickel steel has also decided advantages over all steel. A locomotive is worth perhaps $100 per ton, and where the cost is so largely made up of the wages for labor as it is in the case of a locomotive a small addition to the cost of raw material is of little consequence. Many parts of locomotives, such as axles, of which everybody is so much afraid, tires, framework, etc., could be made of not much more than half the present weight and just as strong.

Quiet use of the metal for various purposes

There is a considerable quantity of nickel being used now in Great Britain and the continental countries, but the trade is carried on quietly, and perhaps the only persons who could give information about it besides the manufacturers are the refiners, who generally know for what purposes their customers are using the metal. It is quite possible that locomotive tires are being made out of nickel steel in Germany, and doubtless a big trade will be done in that line. It seems likely that these German nickel steel tires are displacing the tires of English make, but if so it will not be long before Englishmen use the same material

British Government purchases for experimental objects.

The British Government has been using a large amount of nickel in one way and another, but chiefly in making experiments. A firm in Glasgow got an order eighteen months ago which took up 20 tons of nickel, and this would have been regarded as an unprecedented order ten years ago. But the British Government is conservative of new methods, and its officials must be well persuaded before advising a change from good to better.

Chief uses of the metal twelve years ago.

Twelve years ago, when the production of nickel was 1,000 tons and the selling price about $1.20 per pound, the chief if not only uses of the metal were for German silver, body for electroplating and for coinage. Its present uses include these, with the difference that coins are now being made of pure nickel instead of nickel alloy as formerly. The Austrian Government intends to adopt it for this purpose, and it is rumored that they have given the French nickel company an order for about 3,000,000 pounds. It is only a rumor, but those who profess to know say that the company has received the order, and that it is probably for a larger quantity, spread over five or six years.

The French nickel company's enterprise.

Twelve years ago this French company refined 300 tons a year; today it is refining about 4,000 tons, having got the bulk of the expansion. It has gone on steadily improving its processes, and a great factor in cheapening operations has been the increase of production. But of course many blunders have been made. That is inevitable in dealing with any new enterprise of this kind, the details of which must be mastered experimentally. The producer of pig iron, copper, gold or any other of the staple metals, can usually sell his metal as fast as it is produced to some person or other. If the price is made a little less than market rates, some one will take it; but the man who produces refined nickel must hunt up his own customers, and they are few in number. The demand today is not so great as the supply, but so soon as the metal is produced at 35 or 36 cents per pound instead of 42 the consumption may be expected to grow rapidly. And no doubt it is possible to sell nickel at these prices if the requirements of the market would justify operations on a larger scale than appears to be prudent to enter upon now. A thoroughly practical man says: "I can lay my hand on a mine tomorrow that would show a splendid result at these figures, but it is not every mine that can do so."[17]

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[16] Mr. Ian Cameron, manager of the Dominion Mineral Company's works at Sudbury, informs me that it was through smelting New Caledonia ore, which is free from sulphur, that the first nickel steel was made. "Garnier had a high furnace similar to an iron blast furnace, and he put his nickel ore through that furnace and smelted it as if it was iron ore. Every particle practically of the iron and nickel in the ore was got out—though there was a pretty heavy loss of nickel and iron in the slag—and the result was a very good ferro-nickel, which led to the making of nickel steel by Mr. Marbeau, then one of the Directors of Le Nickel, who started the Ferro-nickel Company in France, at or near the German frontier. This company induced the Steel Company of Scotland to experiment with nickel steel, and Mr. Riley, the manager, told me that if it had not been for his company stopping him they would now be making all the boiler plate in Scotland of nickel steel. But the trade got brisk, and the company had enough to do without experimenting."

In a recent communication Mons. Jules Garnier, the French metallurgist who has been prominently connected with the development of the nickel industry, gives the results of a number of tests made in September, 1892, at the Cleveland Rolling Mill Company's works, to determine the relative quality of steel with and without the addition of nickel. The two steels differed only in the amount of nickel added to one of them, the quantity being about 3 per cent. The method of manufacture and the charges of both heats were absolutely identical. The ingots for both heats were rolled into boiler plates under ordinary conditions. The tests show the following general results: (1) Nickel steel has on an average a higher limit of elasticity of 11,400 lb. per square inch, or nearly 31 per cent. (2) Nickel steel has an ultimate tensile strength greater by 10,400 lb. per square inch, or an increase of about 20 per cent. (3) The ductility is not reduced by the presence of nickel. The nickel used was made from Sudbury ores at the Brooklyn Nickel Works, near Cleveland, a refinery built according to the plans of Mons. Garnier.

Lower price will give an impetus to demand.

Rolled nickel for plating or welding.

Several years ago Mr. Wharton of Philadelphia, as already mentioned, began the plating of material by rolling refined nickel into thin plates and then pressing or welding it on both sides of a sheet of iron or steel; but he does not appear to have developed this application of the metal into a regular business. The process gives a very good article, but it is a little troublesome. A slab of nickel and a slab of steel may be rolled together so as to show a steel face upon one side and a face of nickel upon the other; or nickel may be rolled upon both sides of the steel, and when planished it presents a very attractive appearance. But results almost equally good as regards appearance may be obtained by dipping or electroplating, and the rolling process has not therefore come into general use.

Body for electroplate and white metal alloy.

Uses of white metal.

At the present time the most promising uses of nickel are for the manufacture of body for electroplating, and the making of white metal alloy which does not require electroplating. If 25 or 28 per cent. of nickel is added to a white metal alloy the material is nearly as good as silver plate, and it can be kept clean with infinitely less trouble, besides being of uniform color and quality throughout the whole of its substance. A cheap electroplated article will cost as much as or more than a solid white metal one, and after the coating has worn it is an unsightly thing of patchy yellow. Door fittings if made of white metal would cost perhaps 10 per cent. more than brass; but they would always be bright and clean, and easily kept so. A gas bracket weighing 10 pounds, if made of white metal instead of brass, would consist of 2½ pounds of nickel and 7½ pounds of brass, the former costing

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[17] The New York Engineering and Mining Journal of May 13th, 1893, says: "One thing definite may be said, we think, about nickel. The decline in its price which has taken place during the last two years will be maintained, and in all likelihood it will go still lower. There has been recently an industrial revolution in this metal equal in importance to that which followed the opening of the mines in New Caledonia. The discovery of the Sudbury deposits, and the Orford process by which nickel-copper matte can be cheaply and successfully treated, have made America independent of the world for its supply of nickel, and it now threatens the European markets, the cost of production having been brought below that of the metal of New Caledonia. European metallurgists have not been standing still however, for an improved process, the invention of M. D. Levat, formerly director-general of the Société le Nickel, has already been put in operation at Havre, France. This is a dry process; indeed, it may be said that the day of wet processes for nickel-winning is past."

The Engineer of London, Eng., of January 6th, 1893, also says: "The remarkable discovery of the volatility of nickel in carbonic oxide, due to Mr. Ludwig Mond, is according to a statement of the discoverer to be utilized upon a commercial scale, but it is not known whether the works have as yet been started. The older processes of obtaining the nickel have been improved by the adoption of continuous reduction furnaces, instead of crucibles, and in other details without much alteration of principle, and particular attention has been paid to the production of ferriferous metal for steel makers by Mr. J. Garnier and others; the modern practice of nickel smelting so far as it can be made public having been treated in considerable detail by M. Levat. In consequence of the large supplies coming from Canada and New Caledonia, the price of the metal has continually declined in spite of the new demand in Europe for military purposes, about 500 tons per annum being now required for the bullet casings in the new small arms ammunition. The alloy, one of nickel to four of copper, used for this purpose seems to possess many valuable properties, and it has been suggested as a substitute for copper in locomotive fire-box plates."

$1.05 and the latter 75 cents, or $1.80 in all. There is perhaps $10 worth of labor on it; so that the increased cost through putting 25 per cent. of nickel into it would be only a fraction of the total cost, while a handsomer article and one more easily kept clean would be the result. Hotel bath and lavatory fittings, etc., are now being made of white metal, and one manufacturer in the old country is said to turn out $1,000,000 worth in a year. "There is a large trade growing up," a gentleman engaged in the production of nickel informs me, "in the displacing of brass for lamps, chandeliers, electroliers, door and railway carriage fittings, etc. White metal for these purposes is largely taking the place of brass. It is dearer, but it is ever so much brighter, prettier and easier to keep clean; it tarnishes very little and a light rub will restore its planished appearance, whereas brass requires continuous labor to keep it bright. I have seen a butcher's shop in the old country the walls of which were wholly lined with white tiles, and all the fittings, brackets, hooks and nails were of white metal. The effect as seen by gas light from the street was very fine, and it really enabled the butcher to add a little to the price of his beef. The white metal trade is the one we prefer."

Bullet casings of nickel-copper.

Another use found for the metal in Europe is in the making of bullet casings for small arms ammunition. For this object an alloy of one part nickel and four parts copper has been adopted, and factories producing ammunition for military small arms are requiring now 500 tons of nickel annually in the manufacture of bullet casings alone.

Misapprehension regarding the demand for nickel.

No little misapprehension however prevails as to the demand for nickel. There are some who declare that there is no limit to the quantity which the markets are capable of absorbing, and that some cause of policy, or want of capital, or lack of enterprise is blocking the wheels of progress in the Sudbury mining district. If Sudbury was in the United States, we are sometimes told, the woods would be alive with prospectors, mining camps and smelting works; millions of capital would be invested there, millions of tons of ore would be raised and treated annually, refining works would be established, and Sudbury would supply the world with the pure metal. Such is the language of dreamers, and men who have mining locations to sell. But men who know the trade do not speak in that way; neither do men who have a knowledge of how industries grow. On this subject I have obtained a short statement from Mr. Ian Cameron, manager of the Dominion Mineral Company's works, and a man of large experience in nickel:

Responsiveness of consumption to a drop in price.

"The break in price which took place eight or nine years ago, when nickel fell from 2s. 6d. per pound to 2s," Mr. Cameron says, "led to such an increase in the demand that we could not supply it. When I built the old smelting works for the French company at Kirkintilloch in Scotland I completed one furnace and was then instructed to put up other two. I actually erected five, and with twelve the company could not until the slackness of a few months ago overtake the work. The furnaces are small, and together they run about 4,500 tons per month. The ore is peculiar; it contains about 8 per cent. of nickel and does not lend itself to treatment in large quantity. If it could be as easily fluxed as the Sudbury ore the furnaces could run through an enormous quantity. I think the supply of nickel is greater than the demand, and that this is the reason there is no greater expansion of the industry in this country or in New Caledonia. The demand is not by any means unlimited; we have got to make our trade as we go along."

The present supply greater than the demand.

Of course if there was an active and fast growing demand for nickel, miners and metallurgists would be found ready to supply it; and owing to the position of the mines in this Province and the great extent of the deposits capitalists would easily be persuaded to invest money for mining and treating the ore if there was a sure prospect for unlimited sale of the product and of large profits being realized. There is no hindrance to investment in Ontario, and in the matter of large workable bodies of nickel ore this Province as far as

No hindrance to investment in Ontario.

Some drawbacks to be overcome.

yet known possesses a monopoly of it on this continent. There are drawbacks, but they are not insurmountable. As regards two or three of these I quote again from Mr. Cameron :

"The supply of nickel in the Sudbury district is unlimited, and there are a great many properties which have not been opened up. The New Caledonia ore, some of which occurs as a silicate and some as an oxide, averages as taken out of the mines from 5 to 6 per cent. of the nickel. I have got ore from there testing 25, 35 and 40 per cent. of nickel. This ore cannot be washed ; it can only be cobbed or picked. The native laborers are set to cob it ; they are good enough for that, and men, women and children may be employed at this work at a very low rate of wages One trouble in this country is the dearness of labor, which costs as much as fifty per cent. of our whole expenditure. The duties upon stuff we buy also run up to a high percentage ; for example, the duty on coke amounts to 8 or 10 cents per ton of ore. The net value of 3½ per cent. ore after paying all costs at present selling price cannot be more than $1 per ton, the royalty on which at 3 per cent. would be three cents per ton. The duty on coke therefore is three times as much as all that would be paid to the Government for royalty."

NewCaledonia ore and its preparatory treatment.

Cost of labor in Ontario.

Duty on coke.

Royalty.

As regards refining, Mr. Cameron says :

Refining.

"I do not know that it would be a very great advantage to have the refining of nickel done in this country. According to present practices acids are required, and these cannot be bought as cheaply here as on the other side of the Atlantic, and there are other things that we would have to import. Another disadvantage is that freight charges on refined nickel going to Europe would be greater than on matte. The rate on 100 tons of matte containing 50 per cent. of nickel would be $6 or $7 per ton ; but owing to risk of carriage 50 tons of refined nickel would not be carried at $12 per ton. I do not think there is much hope of refining nickel in this country until the consumption here has greatly increased, or until chemicals and other necessaries in refining can be bought as cheaply as in England or France, or until a successful dry process has been introduced. We could not refine here according to present practices and under existing conditions and hope to sell the nickel in Europe, as there is a heavy duty on the fine metal in France and Germany as well as in the United States. There is of course none in Great Britain."

No cause for discouragement.

In the present state of the nickel industry there is no well-founded cause for discouragement, except perhaps in the minds of extreme optimists with locations of unknown value on their hands to sell. Remembering that it is a comparatively new metal, and that until a few years ago its ore was scarce and hard to treat, the rank to which it has already attained is calculated to excite a feeling of wonder. The progress of operations in this Province in view of every circumstance, and especially of the fact that the largest refining concern in the world is also chief owner of the only mining properties which can compare in richness and extent with those of Ontario, has certainly been as active as the state of the market for the metal would seem to justify. Mining and smelting the ores had their beginning here less than seven years ago, yet measured by the number of men employed, the amount of wages paid for labor and the value of product last year there are only six iron working industries of the Province, as shown by the census of 1881, which exceed this one ; and among those are such old and stable industries as agricultural implements, blacksmithing, and foundry and machine shops. Of iron mines there is not one that is worked, although we have iron ores in great abundance ; neither is there one blast furnace to smelt iron ore, although we consume in the Province upwards of 300,000 tons of pig iron every year. All the indications point to a steady increase in the consumption of nickel ; and the number and variety of new and valuable uses which are being found for it give assurance that the industry is firmly rooted and will grow.

Progress of the industry in Ontario.

VIII.

THE METALLURGY OF NICKEL.[1]

By Mons. David Levat.

Garnierite, the nickel ore of New Caledonia.

Nickel is found in New Caledonia in a single mineral, Garnierite or Noumeite, a hydrated silicate of nickel and magnesium, of a bright apple-green color when pure, which is deposited in concretionary masses or cratings, in the fissures of a serpentine rock. This silicate is not a product of secondary decomposition, no traces of sulphides or arsenides of the metal having been found even in the deepest workings, and the mode of occurrence indicates clearly that the mineral has been deposited by water in the form in which it is now found. In a collection of specimens brought to Paris by Mons. Peletard, an engineer who has lately published a geological map of the island, impressions of insects have been found which are referred to living forms. The distribution of the mineral through the serpentine matrix is not an arbitrary one, it being always found at or near the contact of the rock with the red clays, filling basins or cavities in the rock, but never in the clay itself. These masses of clay are products of the decomposition of the serpentine, and contain all its constituents, in addition to manganese, cobalt and chromium. The thermal springs that have given rise to these clays follow lines of fissure having a general northeast and southwest direction. These clay deposits, which are often covered by considerable deposits of oolitic brown iron ore, contain irregularly stratified masses of cobaltic manganese ore, with 2.5 to 3.0 per cent. of cobalt and chromic iron ore, a granular or so-called alluvial form, which latter mineral is also found in veins in the solid serpentine.

Occurrence and mining of the ore.

The nickel ore, which is newer in origin than those of manganese and cobalt, is found as a vein matter in hollows resulting from the shrinking of the red clay from the sides of the rock-funnel enclosing it. These veins vary very much in size, the maximum breadth being about eight metres; but in some cases the whole of the rock is filled with small veins of mineral, so that it may be worked as a whole up to a thickness of 250 feet Only the larger veins in the hard rock can be worked by systematic mining, as the walls are very irregular and may easily be lost in driving levels; by far the larger number of the workings are in open cast, at altitudes varying from 300 to 600 metres above the sea level, where it is easier to follow the richer developments, and with a comparatively small preliminary outlay to make provision for some years of quarry working in the same locality. The preliminary working is mainly in the direction of removing the red clay, which can only be imperfectly separated from the ore by washing; and the iron ore it contains, if left behind, impoverishes the yield of nickel, besides being objectionable in the smelting by reason of its adding alumina to the charge, which is sufficiently refractory from silica. These works are often a source of considerable expense on account of the falls caused by the heavy spring and autumn rains and the difficulty of obtaining sufficient labor.

Classes of labor employed at the mines.

As regards the latter point, apart from free white men, who are mainly employed as artisans or sub-managers, at the Australian rate of wages of 12s. to 16s. per day, four different sources of labor are employed, namely, assigned convicts, those on restricted leave, natives and New Hebrideans of the Kanaka race, and Chinese, Annamites and Tonkinese. The first two classes are very unsatisfactory, and the Kanakas, although of value for transport and lighterage service, are unfit for mining purposes, being unable to stand exposure to the mountain air, and as a rule the tribes object to working about their own homes, so that the work is principally done by immigrants from the New Hebrides; while the labor in the coffee plantations of the latter islands is largely furnished by New Caledonians. The Chinese are valuable workmen, but the supply from China proper, owing to political and diplomatic complications, has of late years been completely stopped; but latterly natives under contract have been brought from Tonquin, and the result appears to be satisfactory, their work, costing about 2s. 9d. per day, being better than that of convicts at nearly double the price.

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[1] This is an extract from a long general memoir on the production and uses of nickel and its alloys, which appeared in the Annales des Mines, Paris, 1892, published by authority of the Minister of Public Works. M. Levat is a civil and mining engineer, and was formerly director-general of the Société le Nickel.

Dressing the ore.

The mineral is carefully sorted by hand at the quarries and divided into rich and poor qualities, the former containing 8 per cent. and above of nickel, and the latter all below that limit. As the hill-side workings are entirely without water, dressing operations can only be carried on in the lower ground. These are confined to simply washing away the red clay, and even this preparation cannot be carried too far without risking considerable loss (up to 3 or 4 per cent.) in the mud washed away. Hence the necessity of carefully clearing away the waste before working the mineral. The quarry waste, containing 3 to 4 per cent. of nickel, is not utilized.

Transportation from mine to shipboard.

The conveyance of the mineral from the mines to the coast is done principally by ropeways, which are mostly of the simplest construction. When the produce is not more than 7 or 8 tons daily, the selected ore is pla cedin sacks holding from 100 lb. to 120 lb. attached to a hardwood carrier, which is placed on the rope and allowed to slide down, for which purpose a slope of at least 18 degrees is necessary, the empty sacks being carried back by hand or mules, together with the carriers, which make 15 or 20 journeys before they are worn out. The spans of the rope range from 500 metres to 600 metres, and in some instances 800 metres. From the lower stations the carriage to the shore is effected in carts or by railway, but these distances are never very considerable, as only the mines within a zone of a few miles from the coast are actually worked. The embarkation is done in lighters carrying 12 tons to 15 tons each, the cargoes being sent direct to Europe, or by transhipment at Noumea and Sydney. During the wool-shipping season steamers and sailing vessels carry ore and regulus at nominal freights as ballast. The direct shipment in large sailing vessels is less feasible, owing to the numerous accidents that have happened in navigating the reefs forming the coast, and the harbor of Noumea being the only one lighted, the other ports can only be approached in daylight and with a fair wind.

Conduct of mining operations.

Mining operations are conducted either by companies with sufficient capital to provide complete means of transportation, or by single miners who work on their own account on exposures which offer facilities for immediate labor and who deliver the ore on specified conditions. The price at which the ores are sold on the spot naturally varies with the market value of nickel and with their contents, rising rapidly as the latter increases, being better able the richer it is to bear the many charges which the ore must sustain before being smelted and refined. Advances in provisions and goods are generally made to isolated miners or small associations of miners, and also even advances of money, which they reimburse by delivery of the ore, so that any active miner in New Caledonia may work with success, even without capital.

Mining rights.

The acquisition of mining property is easy and open to all, thanks to the special mining regulations established in the colony by decree of the governor dated 13th September, 1873. They follow principally the mining laws of Australia, which give an absolute right to obtain any lodes discovered, but have been modified by the decree of 22nd July, 1883, which has remodelled entirely the mining legislation of the colony and constitutes the unique law at present in force.

TREATMENT OF GARNIERITE.

The treatment of the mineral has undergone several modifications before arriving at the present practice. The original plan of Mons. Garnier was to treat it like iron ore by running it into pig metal, which was afterwards to be refined in a reverberatory furnace to ferro-nickel. For this purpose two blast furnaces were built at Noumea, and a refinery with two Siemens furnaces at Septemes, near Marseilles. Only the first part of the process gave satisfactory results, nickel-iron pig metal having been obtained from the richer lumps, ores averaging 9 to 10 per cent. of nickel of the following composition: Nickel, 65 to 68; iron, 29.5 to 23.0; sulphur, 1.5 to 2.5; silica and carbon, 3.5 to 5.0; and other matters 1.5 to 2.5 per cent. But it was found to be impossible to refine this in the reverberatory furnace owing to the presence of sulphur, which has an extremely high affinity for nickel. It was therefore necessary to revert to the old method of concentrating the metal as sulphide by the addition of pyrites or sulphur. The average composition of the ore available for smelting was: Silica, 45 to 50; iron, 16 to 14; nickel, 8 to 7; magnesia, 12 to 10; alumina, 3 to 5; water and oxygen, 16 to 14 per cent. This requires from 25 per cent. to 30 per cent. of bases (oxide of iron or limestone), besides a sulphurizing material. As neither gypsum nor pyrites, free from arsenic and copper, were available for the latter purpose, the charge for the blast furnace was made up as follows: ore, 1000; coral, 300; sulphur, 35; small coal or coke 75 kilogrammes. The greater part of the sulphur passed into the regulus, and a fluid slag was obtained with 48 per cent. of silica, 12 to 13 per cent. of iron, and not more than 0.40 to 0.45 per cent. of nickel; but the local smelting was given up owing to the difficulties in procuring coke, and now the ores are for the most part smelted in England, alkali waste being used as flux.

Garnier's early method.

Local smelting abandoned, and the ore shipped to England.

The consumption of coke is about 20 per cent. of the weight of the charge, or about 30 per cent. of that of the ore treated. Small sized water-jacket cupolas, smelting from 25 to 30 tons in twenty-four hours, are used. The product contains nickel 50 to 55, iron 25 to 30, and sulphur 16 to 18 per cent., the latter being necessary to make the regulus sufficiently brittle to be easily powdered. The subsequent concentration may be done either in the reverberatory furnace or the Bessemer converter. In the former two calcinations, followed by fusion with quartz-sand, are necessary for the removal of the iron. The furnace treats two tons in 24 hours, with the consumption of an equal weight of coal. The operation, which lasts eight hours, is controlled by sampling during the progress, and is stopped when the iron has completely disappeared in order to prevent loss of nickel in the slags, which however are not thrown away, but are returned to the ore-furnace, as they form an excellent flux, besides containing 2½ per cent. of nickel. By the first concentration the iron is reduced to 2.5 to 3 per cent., and by the second to 0.5 to 0.75 per cent., the sulphur being kept to 16 per cent. at least. In the Bessemer converter the concentration is more rapidly done; a charge of one ton of regulus melted in a cupola is introduced into the converter and blown with air at a pressure of about forty centimetres of mercury. The temperature rises from the combustion of the sulphur, and sand is added to flux the iron. If the proportion of the latter metal does not exceed 36 per cent. it may be completely removed in about one hour and twenty minutes, but with a larger quantity the bath should be skimmed after blowing for twenty-five minntes and fresh flux added, as the fining will be imperfectly done if too large a quantity of slag is retained in the converter. When the slags begin to show signs of containing nickel-oxide the refined metal is poured into moulds. Arsenic, antimony and silver are removed either in the slags or by the blast; cobalt remains with the nickel-sulphide. The converter slags are much richer than those of the reverberatory furnace, containing from 14 to 15 per cent. of nickel, mostly as shots of diffused regulus, which may in part be collected by

Furnace treatment, and subsequent concentration to eliminate iron and sulphur.

running the slag into conical pots and separating the cake of metal at the bottom. The whole of it must in any case be returned to the ore furnace. Attempts have been made to continue the blowing up to the complete removal of the sulphur to produce a material that would only require a final reducing treatment to obtain pure nickel. This has however been found to be impossible, owing to the high affinity of nickel for sulphur, the heat developed in such an after blow being less than sufficient to counteract the cooling effect of the air, and as the product when free from copper has a high melting-point, approximating to that of iron, it sets very rapidly, and blocks up the tuyeres.

Refining the regulus.

The refined regulus, whether obtained from the reverberatory furnace or the converter, consists essentially of nickel-sulphide (or nickel and copper sulphides, if obtained from pyritic ore like that of Canada), with not more than 0 50 per cent. of iron and the same proportion of other foreign matters. It is crushed to pass a 65-mesh sieve, and charged in quantities of 600 kilogrammes upon the bed of a reverberatory calciner 10 metres long and 2 50 metres broad, with four working doors on one side, forming a layer about two inches thick, which is constantly rabbled and moved gradually from the flue of the fire-bridge end. The operation lasts eight hours with pure nickel-sulphide, and only six when the regulus contains copper. The consumption of coal is 2,000 kilogrammes for 2,400 kilogrammes of material roasted. The temperature is kept to a dull redness, except towards the end, when the furnace is raised to a bright red heat. The finished product, which should not contain more than 1 per cent. of sulphur, is ground to pass a sieve of 120 mesh, and subjected to dead roasting in a furnace of the same breadth as the preceding one, but with a shorter bed. The charge is 500 kilogrammes renewed every six hours, and the temperature is kept at bright redness; three tons of coal are burnt in 24 hours. The product is nickel oxide, or nickel and copper oxides, and should not contain more than 0.40 per cent. of sulphur.

Reduction of nickel oxide.

The reduction of the oxide is effected by mixing it to a paste with flour or other organic matters, dividing into small pieces when dried, and strongly heating with charcoal powder. Formerly the paste was cut into cubes of 12 to 15 millimetres, but in France disks of regular shape, 50 millimetres in diameter and about 15 millimetres thick, made in a press, are preferred. They must not be made thicker, or the reduction will be imperfect in the centre. The Chinese, who are somewhat considerable consumers of nickel, prefer to have it moulded into ingots similar to those used as money in China. Formerly the reduction was effected in crucibles holding 50 to 60 kilogrammes in a gallery or reverberatory furnace, but owing to the imperfect and irregular heating the process was very wasteful of fuel, and the pots did not last for more than five or six operations. This method has therefore been abandoned in favor of furnaces working continuously. The first of these is a large muffle 3.5 metres long and 1.8 metres broad, heated by the flame of a gas furnace, which is passed several times around it by a series of spiral flues. The shorter sides are closed by balanced doors, and the iron pots containing a mixture of oxide and charcoal are subjected to a gradually increasing heat for 24 hours, being entered at the coolest side and pushed gradually nearer to the fireplace. This with mixed oxides gives a coherent product; but pure nickel oxide, although it is reduced by carbon at a comparatively low temperature, must be subjected to a temperature of 1,100° or 1,200° for four hours to obtain the coherent metallic character required by the customer; and as such a heat is unattainable in the muffle, the operation must be finished in a crucible.

An improved plan.

Another and more improved plan of reduction is in a regenerative furnace resembling that used for reducing zinc oxide in Belgium, but having retorts open at each end. The mixture of oxide and charcoal is charged by a semicircular scoop at one end, and when finished the charge is pushed out at the other end into closed receivers, where it is allowed to cool out of contact with the air. A furnace with 22 retorts is capable of reducing 1,500 kilogrammes of nickel oxide or 3,000 kilogrammes of nickel-copper oxides in 24 hours, the charge of 750 or 800 kilogrammes requiring ten hours in the furnace in the first and five hours in the second case. About two tons of coal are required for heating in the twenty-four hours, and the work is done by two men per shift of 12 hours. The reduced metal is sifted to separate the cubes or disks from irregular and broken masses, which are afterwards collected by a magnet. The former are polished by friction upon each other in a rapidly rotating barrel, while the latter is added in packing the barrels to make up the exact weight of 100 kilogrammes.

Nickel-copper alloy.

Among the more important recent applications of nickel is that of the alloy (nickel 20 parts, copper 80 parts) for the casing of bullets for the small-bore rifles adopted in modern armaments. This combines a higher tenacity than that of the best brass with a high co-efficient of elongation, the former being from 28 to 31 kilogrammes per square millimetre, and the latter 25 to 35 per cent. and exceptionally as much as 39 per cent. in the metal as cast. The co-efficient of elongation increases with the freedom of the alloy from iron. By rolling cold the tensile strength is increased to 60 or 62 kilogrammes and the elongation is diminished to 3 or 4 per cent. When annealed under the most favorable conditions the strength is 30 to 40 kilogrammes and the elongation 32 to 39 per cent., compared with copper, where the corresponding figures are 25.1 kilogrammes and 34.1 per cent. The annealing of this alloy is a very delicate operation, requiring special manipulation, the details of which are mostly kept secret by the manufacturers. The principal object is to avoid oxidation, and this according to the author may be most effectually done by separating the sheets in the annealing piles by sheets of cardboard, which are carbonized during the process. If badly annealed, the mechanical properties are altered in a remarkable manner, the burnt metal having a tensile strength of 30 kilogrammes, with only 1 per cent. elongation. In a general way the annealing is considered to be bad if the tensile strength is below 33 kilogrammes and the elongation less than 30 per cent. The elastic limit is from 11 to 15 kilogrammes when well annealed and 45 kilogrammes when the metal is hard from the rolls. The ready malleability of this alloy seems to render is particularly suitable for locomotive fire boxes, and plates for this purpose were exhibited by the Societe des Metaux at the last Paris Exhibition.

M. Levat also treats of the nickel deposits of the Sudbury district, recounting various facts in connection with the geological formations in which they are found, their manner of occurrence, etc. As to the mining operations there he says :

TREATMENT OF SUDBURY ORES.

Extent of the deposits.

The working of the Sudbury deposits is concentrated in the hands of several companies possessed of ample means and improved appliances. Only those mines close to the railway are at present worked, but there are many analogous deposits still unknown, unworked or insufficiently developed, owing largely to the difficult nature of the country. Nevertheless, according to an official report addressed to the Secretary of the United States Navy in October, 1890, there had been exposed at that time in the various workings a mass of ore calculated to contain not less than 650,000,000 of tons, the total quantity raised up to that time for a period of two years only being about 160,000 tons. These figures sufficiently indicate the economic and industrial importance of Canada as a producer of nickel. The average contents of the ore do not exceed 3 to 4 per cent. of nickel and about the same of copper. The ores of the Canadian Copper Company appear relatively less rich in nickel than those of the Dominion Mineral Company, but both seem to increase in contents of the useful metals in proportion to the depth of the workings.

Smelting the ore.

The smelting of the roasted ore is the most interesting part of the local treatment of the Canadian mineral. It is done in large water-jackets with steel plating of 3 millimetres and of elliptical form, made in one piece from the hearth to the charging door. The hearth itself is closed by a plate of iron covered with fire-clay. Furnace No. 1 of the Canadian Copper Company smelted in 259 consecutive days 31,268 tons of ore, an average of 120 tons every 24 hours. No. 2 ran for 73 days, smelting 9,740 tons, or 133 tons every 24 hours. The low height of the furnace avoids the reduction of the iron and the formation of "wolves." The coke consumed during the campaign above mentioned was 5,107 tons, which smelted 41,000 tons of ore, an average of 12.5 lb. of coke to 100 lb. of ore. The coke, which contains 10 per cent. of ash, comes from Pittsburgh by lake and rail, and costs delivered at the smelters 35 francs per ton. The matte produced in the same time amounted to 5,059 tons, about 12 per cent. in weight of the ore smelted, almost exactly the same proportion as that of the coke used. In other words, 1 ton of matte requires for its smelting 1 ton of coke. The slag is very basic, as the following analysis will show :

Matte and slag.

SiO_2	38.00 per cent.
FeO	43.00
CaO	4.50
Al_2O_3	10 00
S	2.00
Ni	.45
Cu	.40
MgO	2.50
	100.85

At first the mattes contained more copper than nickel, which proved disadvantageous in their subsequent treatment, the refiners charging more as the proportion of the copper exceeded that of the nickel. In 1889 the mattes contained, according to the analyses of the Canadian Copper Company,

Cu	26.910 per cent.
Ni	14.140
Fe	31.235
S	26.950
Co	.235
Slag	.935
	100.405

By selecting out the purely copper ores for separate treatment the nickel contents of the matte have been increased. In February, 1891, the mattes contained

Cu	16.94	16.95	17.84
Ni	19.40	21.47	23.45

The charge in the Dominion Mineral Company's furnace is composed partly of purely nickeliferous ores produced by certain of its mines. That company's mattes contain

Cu	18 to 20 per cent.
Ni	24 to 26

Relation of cost of production to price of fine metal.

The cost of smelting at Sudbury may be estimated at between 8 and 9 francs per ton of ore. Manual labor comprises only about 2.25 to 2.50 francs per ton of this cost, notwithstanding its dearness. The workmen employed at the furnaces receive on an average 9 francs per day of eight hours. Each furnace employs per shift 1 fireman, 1 weigher, 2 founders, 3 men to take away the slag, and 3 shovellers. The entire plant is organized in such a way that the handling of the ore from the mine to the furnace is reduced to a minimum. In fact the ore is handled only four times from mine to smelter, and each delivery, save to the roast heap, is effected by means of hoppers with inclined bottoms discharging directly into waggons. As has been already stated the average cost of mining the ore is at present 10 francs per ton, thanks to the open workings, the output of which comprises a large part of the total production, and which enable the ore to be mined cheaply. This resource must in the future become exhausted and subterranean workings only resorted to, the cost of mining from which is about 15 francs per ton. This sum must necessarily increase in proportion to the difficulties met in the underground workings, and notably on account of the barren stretches, which will be considerable. It is true that there is good ground to hope for an increase in the nickel contents of the ore as the depth increases, but even on the basis of present results and a cost of from 20 to 25 francs per ton for mining and 10 francs for roasting and smelting it is evident that ores having an average contents of two to three per cent. of nickel and the same of copper will produce a matte in which the useful metals will carry a cost of 1 franc 50 centimes per kilogram of nickel contained, and 50 centimes per kilogram of copper ; that is to say a cost very much lower than the probable market value of these metals in the future, all charges of refining being deducted.

Low cost of reduction to matte.

Balancing considerations.

. . . To sum up, the Canadian ores, notwithstanding their relatively small percentage of nickel can produce this metal in the form of matte enriched to 20 per cent. at a very low price. This is due in great part to the ease with which the ores are treated and the richness of the deposits. The matte, besides nickel, contains copper, which must be separated by a distinct operation if it is desired to obtain pure nickel, while the mattes of New Caledonia do not require this supplementary process. It is true that these additional expenses are covered by the value of the copper, the refining of which is much simplified by the very fact of its separation from the nickel. On the other hand, the New Caledonia ore must go through a preliminary smelting before being given over to the refinery, while the Canadian mattes can be refined directly without a new concentration. These different considerations seem to balance each other, and it would seem that the two countries which are producing nickel at this time can strive with equal advantage so far as their respective cost of production is concerned. The advantage would certainly be with Canada if nickel were employed principally for making white alloys, as for this purpose it is only necessary to refine the nickel and copper together, but this method of employment seems to be more or less falling into disuse, and is being replaced by the use of pure nickel, especially for alloys with iron and steel.

THE NICKEL OF COMMERCE.

Impurities and alloys.

The nickel of commerce contains in general 1.50 per cent. of impurities, the principal of which, iron, has no injurious influence in the uses to which it is destined. It contains also carbon in the free state and combined, oxygen, a little sulphur and other foreign matters derived from the wasting of the furnaces. Nickel-copper alloys contain about the same impurities. These alloys are delivered in the form of cubes or grains of different compositions, such as 90 per cent. of nickel and 10 of copper, or 75 to 25, but especially in the form of 50 per cent. of nickel to 50 per cent. of copper, approximately. The latter is a definite alloy which must always be taken as a starting point when one wishes to proceed with the manufacture of binary or ternary alloys of nickel. The makers of "maillechort," "argentan," "silverine," etc., usually buy their nickel in the form of the 50 per cent. alloy, and this combination is also the easiest to obtain from the refining of the Canadian mattes. At the same time, as the uses of nickel appear to be developing principally in the line of alloys with iron and steel, uses for which the presence of copper is inadmissible, it has been indispensable to obtain a method permitting of the complete separation of these two metals, and this at a cost not exceeding that of refining the Caledonian mattes, but taking into account nevertheless the cost apportionable to the copper as well as of the fact that the latter is partially refined by the nickel being separated. This question is all the more interesting to the nickel industry because the deposits of Canada form, as we have seen, a factor in their power of production equal to those of New Caledonia.

The question of supply.

One of the difficulties in the way of the employment of nickel in those industries which might consume large quantities, as for example the manufacture of steel, is the fear of a premature exhaustion of the nickel deposits and the uncertainty of procuring the necessary supplies without unduly enhancing the price of the metal. The possibility of employing the nickel of Canada, or, which is the same thing, the possibility of a complete and economic separation of the nickel from the copper, is therefore a problem interesting in the highest degree to the nickel industry.

The problem of separating nickel and copper.

A separation of this kind can hardly, *a priori*, be effected except by chemical means, otherwise the wet process. The question is not a new one, because in the old metallurgy of nickel this metal, almost constantly associated with copper and cobalt, was separated from these latter by various methods, which always made use of the wet process either partially or wholly. There will be found in the works to which I have referred at the beginning of this memoir the formulæ for the methods of treatment by which the separation was attained. These operations, which belonged rather to the laboratory than to industrial practice, were profitable only because of the high price of nickel and cobalt at that period. The copper was, so to speak, sacrificed, and the purity of the nickel was only of very relative importance on account of the uses to which it was destined. The presence in the nickel of a certain proportion of copper was not only not objectionable, but even served to conceal the troublesome effects of the arsenic and sulphur which remained in the metal. None of these methods could answer the end which was desired, namely, the complete separation of the copper from the nickel. It would be tedious to enumerate all the methods proposed or attempted with this end in view. Mons. Badoureau cited in his memoir a large number of them, applied it is true to the ores of New Caledonia, but they have since then become very numerous, and patents have been taken out and are applied for daily for the same object. I recognize only as interesting experiments the processes based on the electrolytic deposit of nickel in a liquor containing copper. It appears possible to produce this separation, basing the process upon the difference in the electromotive force necessary for the decomposition of the salts of copper on the one hand and those of nickel on the other, the latter requiring a much higher voltage than the former. . . . . It is then possible, theoretically at least, to maintain in a bath of the sulphates of the two metals an electric tension below 1.877 volts and deposit the whole of the copy without the nickel. This reaction has been studied by Messrs. Siemens and Halske of Berlin, but I do not know up to the present time of the industrial application of the method. The chemically pure nickel deposited by electrolysis does not appear to conform to all the applications of this metal. It is especially, owing to the absence of carbon, unsuitable for the manufacture of alloys, for which it is necessary to employ the carburetted nickels.

The electrolytic method.

Garnier's new method.

Mons. J. Garnier announces in his work which I have already cited the application by an important metallurgical establishment of the United States of a process for the separation of the nickel and copper in the mattes of Sudbury, patented by himself, but he does not give details on the principle of the separation. This establishment, actually in construction near Pittsburgh, applies the process to the mattes produced by the Canadian Copper Company.

At the establishment of St. Denis, belonging to the firm of Christophle, they treat the ores of New Caledonia by the dry method and by the wet method conjointly. The latter is applied notably to the cupro-nickeliferous mattes obtained by a first fusion with pyrites containing copper and nickel. It is besides an additional operation ; the separation is performed in a hydrochloric liquor. They commence by attacking the matte with hydrochloric acid, and then utilize the freed sulphuric acid for the precipitation of the copper from the solutions obtained in a previous part of the process The iron is precipitated by oxidizing it by calcium chloride and a current of air. Finally the nickel is obtained under the form of a greenish, gelatinous, hydrated precipitate by means of milk of lime. This oxide can be either utilized for the manufacture of sulphate of nickel destined for electroplating, or dried, calcined and reunited to the oxide obtained by the dry way in order to be passed on for reduction.

Conjoint wet and dry processes.

The trouble with the oxide of nickel precipitated by lime is that it always retains a certain quantity of the impurities of the milk of lime employed for its precipitation. If liquid containing sulphates is worked with, one has moreover the inconvenience arising from the presence of the sulphate of lime dissolved in the water retained by the gelatinous precipitate of the hydrated oxide, which is very voluminous. This salt remains in the nickel throughout the calcination, and introduces during reduction sulphur into the metal. This latter trouble can be avoided by precipitating the dissolved sulphate of lime by chloride of barium before effecting in the hydrochloric liquor the precipitation of the nickel by milk of lime, or separating the sulphate of lime after calcination by treating it in the crucible with carbonate of soda. The part not melted is the purified oxide, but both these methods increase the cost of refining by the wet way. This difficulty of the purification and washing of the oxide of nickel precipitated by a base in a hydrated and gelatinous condition renders the adoption of the wet process, properly so called, impossible for the treatment of large quantities, or at least makes necessary the construction on an extraordinary scale of precipitation vats and washing apparatus, combined with filter presses requiring much hand labor, to obtain after all a product, the oxide of nickel, pressed into cakes, still containing more than 60 per cent. of water.

The Herrenschmidt process completely overcomes this difficulty in this sense, that the nickel is separated without requiring any precipitation, and that this separation takes place in the body of very concentrated solutions. Without entering into details of this operation, which I am not authorized to do, I may indicate that in principle this complete separation is obtained by the fixation of the copper by the nickel and the iron of the matte itself, and there is obtained on the one side the whole of the nickel in concentrated solutions which need only be evaporated to be transformed into an oxide by roasting and to be reduced by the ordinary process, and on the other side a cement of copper which requires only to be refined in order to be put into merchantable form

PURE NICKEL.

The nickel of commerce, containing 98 or 99 per cent. of that metal, the manufacture of which we have just described, is not properly speaking a metal. It is rather a sponge of reduced particles artificially agglomerated, and consequently without cohesion. In order to study its properties and to utilize it, it is necessary to melt it in a crucible, an operation which requires a high temperature and much care, because nickel, which is unattacked by atmospheric agents at ordinary temperatures, oxidizes very readily at a red heat, and its oxide dissolved in a bath of the metal renders the latter brittle. It is also necessary to avoid contact with carbon, which would give a steel or even a casting of nickel with a considerably lower melting point. The operation is in general performed in a crucible under a layer of flux, and the metal is run into sand or shell according to the kind of articles it is desired to obtain. It is in this way that cast anodes destined for electroplating are made.

Nickel of commerce treated in the crucible.

When the nickel is to be rolled there is added in the crucible a few minutes before casting a small quantity of some reducing metal, easily oxidized, such as, Qualities of pure nickel.

magnesium, manganese or aluminium. Care should be taken to place this meta at the bottom of the crucible with a bar of pure nickel, or in refractory clay. It is probable that independently of the reducing action these oxidizable metals, especially aluminium, act on the oxide of carbon dissolved by the nickel, as has been shown in the recent works of Mr. Hatfield on the action of aluminium in the casting of steel. Pure nickel obtained under this form is malleable, ductile, and easily forged. Its tenacity is intermediate between that of iron and steel, and according to Deville its point of rupture is 90 kilograms per square millimetre. It melts like iron at a high temperature, softening at about 1,200 degrees. The presence of carbon renders it almost as fusible as cast iron. The density of the pure metal is 8.38. Its electric conductivity is almost exactly that of iron. We know too that nickel is magnetic. According to Poullet, it loses its magnetism at a temperature of 350 degrees. It is magnetized under the same conditions as soft iron. Under the influence of feeble magnetizing currents it is magnetized five and a half times more than iron, but with magnetic currents of considerable strength it is magnetized five times less. The question of the temper of nickel has not yet been completely studied. Denied by Boussingault, who probably had not at his disposal at that time (1878) nickel sufficiently pure, it has been recognized that nickel forms with carbon true steels and true castings. The question is at present being studied, and it is probable that in a short time the conclusions arrived at may be made public.

Nickel-plating.

Nickel is rolled hot as easily as iron. It is forged, as before stated, and is welded to itself or to iron. This latter property has given rise in Germany, Switzerland and France to the industry of nickel-plating by welding two plates of given relative thickness, one of nickel and the other of soft iron, previously well scoured, by means of rolling them together. The two metals having similar coefficients of ductility preserve during the rolling their proportional thickness in such a way that one may obtain at will a plate of a tenth, a twentieth, etc. The iron may also be plated on both sides and in this condition employed in place of pure nickel for a multitude of uses and domestic objects, the more readily as this hot-plating, or more properly welding, has not the defect of scaling off during use as the electro-plated ware has. Nickel plated wire in virtue of the same principle may also be manufactured and drawn out to any desired number. The same operation, whether for the plating or the wire, can be carried on with nickel combined with copper. These sheets, plated on one or two faces, will take on a beautiful polish which is not affected by the air. They are employed notably in the manufacture of parabolic reflectors for lanterns in place of silver. The cost of these is much less than those made of silver, and their polish is as brilliant, although of a darker shade. They are also more difficult to scratch. Such sheets also admit of being stamped for the manufacture of cooking utensils, carriageware, etc.

Uses of pure nickel in leaf and thread forms.

Independently of the plating, the pure nickel in leaves and threads is entering more and more into common use. As it is less malleable and less easy to melt or to mould than copper or brass, the appliances of the manufacturers who employ the latter metals are insufficient to utilize the metal, and on this account there is a certain delay in the manufacture of objects for domestic use. Nickel threads are employed very largely in passementerie. Lyons is the centre of a special industry of gilded and silver laces plated on nickel, which do not tarnish through use like those plated on white metal or brass.

Electrolytic nickel.

Pure nickel is employed under the form of cast or rolled anodes in order to deposit on the surface of various objects previously well scoured a thin layer of electrolytic nickel, to which there is finally given a brilliancy by polishing. Becquerel was the first to make known a process of galvanic nickelling of metals by means of a neutral solution of the double sulphate of nickel and ammonia. This salt is still the base of the baths at present employed, the formulæ of which vary indefinitely. The important point is that the bath does not change and that it remains neutral during the whole operation. This is secured by placing in it the anodes of pure nickel, which are dissolved in proportion to the metallic deposit upon the objects to be nickelled. The process of nickelling requires a very strong current. A bath of 200 to 300 litres, for example, requires six Bunsen elements of 22 centimetres. For this reason the preference is given to electric-dynamo machines. The nickel bath consists generally of an aqueous solution of ammoniacal sulphate of nickel of 7 or 8 per cent., or say 70 or 80 grammes of metal dissolved in a litre. The bath should remain neutral to litmus paper. There is frequently added to it a substance known as the neutral salt of commerce, a mixture of phosphate and bicarbonate of soda with ammonia. The phosphate and bicarbonate increase the conductivity of the bath. In place of anodes of nickel, insoluble positive anodes of carbon may be employed, in which case the bath must be fed with crystals of ammoniacal salt of nickel. The foreign metals which would spoil the bath are precipitated by the daily addition of small quantities of sulphate of soda. The hot baths give the most brilliant precipitates, but less solid than those given by the cold baths. When the object is removed from the bath it is dipped in hot water and then dried in sawdust, and finally placed in a cloth and polished by the burnisher.

New process of nickelling.

Heretofore nickelling has been done by the electro method. There is a new process based on a very curious reaction of nickel. Messrs. Mond, Land and Quincke have shown recently that if carbon monoxide be passed over nickel, beginning at a temperature of about 30 degrees, the two bodies unite and give a combination which may be condensed into a liquid boiling at 43 degrees. The nickel can be obtained by a reduction of the oxide by means of hydrogen. This very volatile liquid can be dissolved in benzine and petroleum. In vapor or in solution it is decomposed with a brilliant deposit of nickel under the influence of a slight elevation of temperature. In order to cover objects with a coating of nickel they are immersed in a solution or in the heated vapor at an elevated temperature. If it is desired to obtain plates of the metal by the electrolytic process or otherwise, depositing surfaces are employed coated with a layer of graphite. The processes of M. Mond are very practicable in the laboratory, and are based on an absolutely unexpected reaction which is interesting to note.

ALLOYS OF NICKEL AND OTHER METALS.

Nickel and copper.

Nickel alloys very easily with copper in all proportions. Its action is exercised in the first place on the color of the alloy. As its proportion reaches 6 or 7 per cent. the metal whitens. At 15 per cent. the alloy is clearly white, and this proportion is only exceeded when it is desired to obtain a perfect whiteness. At 25 per cent. the maximum of effect is obtained. An alloy of this kind is susceptible of taking on a beautiful polish, with a clear reflection similar to that of silver. Air tarnishes this brilliancy, but with comparative slowness. Above 25 per cent. the increase of the proportion of nickel has no longer any effect upon the color. The addition of a small quantity of cobalt gives an alloy of perfect whiteness, even when the proportion of nickel does not surpass 16 per cent.[2]

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[2] "Silverine" or "argentan" has a composition based upon this fact. Following is the formula for the alloy of "argentan" patented by Mr. Pirsch:

Cu	79 50	75.00	71.00
Ni....	16.00	16.00	16.50
Co..................	1.00	2.00	1.25
Zn	1.00	2.25	7.50
Sn....	1.00	2.75	2.50
Al..................	.50	.50	....
Fe	1.00	1.50	1.25

The last formula is that of a true maillechort.

White metals.

There is a constant confusion among the names and compositions of binary, ternary and multiple alloys of nickel known under the general designation of white metals. Under the name 'maillechort' an alloy is made of nickel, copper and zinc, containing a maximum of 15 per cent of nickel. The remainder is composed of two parts of copper and one of zinc. 'Silverine,' 'argentan,' 'packfong,' etc., contain other metals as well, such as tin, bismuth or antimony, which impart fusibility and a fine color generally at the expense of ductility. A certain quantity of iron is usually added if the nickel employed does not already contain it in order to give hardness to the alloy. Zinc produces a similar effect. The binary alloy of 90 per cent of zinc and 10 per cent of nickel is easily reduced to a galvanic powder and sold for this purpose under various names.

Production of the alloys.

The preparation, fusion and especially the casting of these alloys are extremely delicate operations, demanding skilled founders in order to obtain regular ingots. Whatever may be the composition desired we must always commence by making an alloy of 50 per cent. nickel to 50 per cent copper, and a sufficient quantity of the latter metal is afterwards added to produce the alloy desired. It is indispensable that the copper added should be of equal quality to that in the 50 per cent. alloy. For this reason certain careful founders prepare this alloy with their own hands. When the fusion is complete and the mass at rest in the crucible, it is stirred with a bar enclosed in refractory clay, the surface skimmed and the copper added, or the oxidizable metals which complete the alloy. A stick of green wood is also used for stirring the molten metal, which is generally cast in shell to prevent its cooling on the sides of the mould. Unlike copper and nickel, the white metals are rolled cold. Maillechort requires several reheatings before it can be made into leaves. These reheatings require minute precautions, which it would take too long to enumerate here. . . The binary alloy, 20 per cent of nickel to 80 per cent of copper, prepared in suitable forms, may be rolled or stamped in the cold with a simple annealing without intermediate reheating. This is of all the white metals the one that has been most carefully studied on account of its applications in the manufacture of ball casings for the new arms of small calibre and great initial velocity. The adoption ef these arms necessitated the modification of the projectile, which would be destroyed or at least distorted in the barrel of the weapon if made of hardened lead as formerly. It was therefore necessary to cover the ball with a rigid case made of a metal sufficiently malleable to conform to the rifling of the barrel, and on the other hand capable of sustaining the explosion without being put out of shape. Lastly, it required an almost unoxidizable metal to secure the safekeeping of the ammunition. These several conditions appear to be realized in the alloy of 20 to 80 adopted by most of the nations of Europe for their new armament. . . An application indicated by the properties of this alloy is its use for locomotive fire boxes instead of copper. It is known that the great difficulty in the manufacture of these articles, besides the large size of the plates to be rolled (which reach usually 3½ metres), is the procuring of uniformly good surfaces, free from flaws, bubbles or other defects which, acting as centres of oxidation, shorten the life of the fire-box. The relative slowness of oxidation of the white metals gives them from this point of view great advantage. But these plates should be scraped with an engraver's tool during the rolling process in order to remedy the faults which may reveal themselves. . .

The manufacture of covers and silvered objects, called 'Roolz,' 'Alfenide' or 'Christophle,' from the names of the principal French houses which deal in this sort of ware, constitutes an important outlet for nickel. The principle is well known, namely that of covering electrolytically a stamped or moulded article with a layer of silver of greater or less thickness. At first the metal

An important outlet for nickel.

upon which this deposit was made was brass, but its use has been rapidly abandoned and replaced by that of 'maillechort,' which has the advantage of not appearing yellow when use has removed the silver coating. In America they even content themselves for the most common uses with covers of white metal not silvered at all, but simply polished, which replace for the western markets the old covers of tin. Hundreds of tons of alloys are consumed annually for this purpose. The valley of Waterbury in Pennsylvania is the centre of this manufacture, favored as it is by the existence of numerous water-falls and by the grouping of a population accustomed for a long time to the working of nickel and white metals. This industrial centre is well known for the manufacture of watch movements and cases of nickel or nickel plate at a low price which sell the world over.

Nickel money.

In a review of the uses of nickel one cannot pass over in silence that which has so to speak vulgarized this metal, namely, its employment, or more exactly that of white metal, for small coins by a large number of countries, especially in the New World, in place of copper. The majority of States which belong to the monetary union have not yet renounced the use of copper coinage, notwithstanding its admitted inconvenience. Following is a list of the countries which have issued nickel money, and the date of the first issues in each: United States of America, 1853, 1864, 1869, 1871, etc.; Switzerland, 1858, 1874, 1881, 1883, 1889; Belgium, 1861, 1862, 1863; Costa Rica, 1867; Peru, 1863, 1864; Honduras, 1869, 1870; Jamaica, 1871; Brazil, 1871; Chili, 1871; German Empire, 1874, 1876, 1888; United States of Colombia, 1874; Japan, 1875; Venezuela, 1876, 1886; Mexico, 1882; Servia, 1883; Equador, 1884; Bulgaria, 1887; Romania, 1891; Argentine Republic, 1891. The issues are in general for 5, 10 or 20 centimes (or pfennigs). For the latter, Switzerland and Germany have struck pieces of pure nickel, which is more difficult to counterfeit and less subject to wear. They replaced pieces of 20 centimes or under in silver which circulated with difficulty. The United States has adopted a type of five cents, of which coins a certain quantity is struck every year in view of the growing needs of the population. . .

Mons. Levat also enters at some length into the question of the alloys of nickel with iron and steel, referring to the experiments of Riley at Glasgow, and to the tests of nickel steel armor plate for war vessels by the Navy Department of the United States. Riley's experiments have already been published in the report of the Royal Commission on the Mineral Resources of Ontario (1890) and the details of the U. S. Navy Department tests are referred to elsewhere in this report, *ante*, pp. 136 8. He goes on to say:

PRODUCTION OF NICKEL.

Increase of demand for the metal.

The production of nickel remained almost stationary until the opening up of the mines in New Caledonia in 1878. It was at that time about 400 tons for the entire world. This figure increased in 1880 to 1,200 tons and to 2,000 tons is 1884. In 1886 the application of nickel to military purposes led to an immediate demand for this use alone of 400 or 500 tons per year, without taking into account the normal increase of consumption due to the development of the applications already known, so that in 1887 the annual consumption for the world may be placed at about 3,000 tons of pure nickel. Of this total the New World and the extreme East consumed about one-fifth, the remainder being used in Europe. At that period New Caledonia was almost the only factor in the production, and produced about 2600 tons of nickel yearly. Since then the mines of Canada, scarcely known in 1888, have undergone a rapid development. They are not hindered in that country by the difficulties of manual labor and transport which impede the work in New Caledonia, as we have already seen. The district of Sudbury, with three or four large

Capacity of production of Ontario and NewCaledonia nickel.

furnaces in operation, is now in a position to produce a daily output of 12 or 15 tons of nickel contained in a cupro-nickeliferous matte, or about 4,500 or 5,000 tons per year. New Caledonia under existing circumstances is capable of a similar production, so that we may conclude that in a short time the total annual production of these two countries will be from 9,000 to 10,000 tons of pure nickel yearly.

Fluctuations of price.

The price of nickel has naturally fluctuated during the period when the new sources of production were being opened. In 1876 a kilogram of refined nickel was valued at about 18 francs. It fell a little later very rapidly to 10 francs, then to 6 francs, at which price it remained for some time. Since 1886 the metal has been more steady in its value, varying between 5.50 and 5 francs, depending upon the magnitude of the transaction. It is probable that the value, looking at the actual provisions for new outlets, will remain for some time at about this quotation. These prices are for the pure nickel refined, because one can deliver nickel either alloyed with the copper of Canada or under the form of the pig iron of New Caledonia at a much lower price, since the great part of the cost of refining will thus be avoided, if it were found possible to utilize to advantage the nickel in these intermediate forms.

IX.

CONSTITUTION OF NICKELIFEROUS PYRRHOTITE.[1]

By Dr. Stephen H. Emmens, President of the Emmens Metal Company, Youngwood, Pennsylvania.

The theory of replacement.

It is the custom of mineralogists to speak of many mineral varieties as formed by one metal "replacing" another to a greater or less extent in certain chemical combinations. This is, I think I may say, the invariable account given in the text-books respecting nickeliferous pyrrhotite, a mineral described as consisting of an iron sulphide in which "part of the iron is replaced by nickel." The object of the present paper is to enquire whether the account in question is a correct representation of the facts of the case, or whether the constitution of nickeliferous pyrrhotite differs from the description given in the text-books.

Formula of pyrrhotite.

The general formula of pyrrhocite is $Fe_n\ S_{n+1}$. This is sometimes written $n\ (Fe\ S).\ Fe\ S_2$ or $n\ (Fe\ S).\ Fe_2\ S_3$; though probably, for reasons analogous to those recently set forth (Journal of Analytical and Applied Chemistry, vol. VI. No. 10, October, 1892), the more correct view is to regard the typical compound, $Fe_3\ S_4$ as being a homogeneous body, and not as being composed of a mixture of sulphides. This question however is comparatively unimportant in the present discussion ; as, whatever may be the precise arrangement of the molecules, their number will not be changed, and pyrrhotite will still be defined as an iron sulphide composed of n molecules of Fe and $n + 1$ molecules of S. And, on the "replacement" theory, nickeliferous pyrrhotite will be a sulphide composed of x molecules of Ni, $n—x$ molecules of Fe and $n + 1$ molecules of S. Let us test this numerical theory by the actual results of analysis.

Analyses.

At p. 74 of the 6th edition of Dana's Mineralogy is a table of analyses of various specimens of pyrrhotite. From this I will select the following for discussion, namely :

		S.	Fe.	Ni.
No. 14.	Brewster, N.Y	37.98	61.84	0.25=100.07
" 15.	Putnam Co., N.Y	39.28	60.03	0.78=100.09
" 15a.	" "	38.99	60.04	1.02=100.05
" 15b.	" "	39.85	58.73	1.53=100.11
" 20.	Frigido	39.65	58.18	2.17=100.
" 18.	Hilsen	40.27	56.57	3.16=100.
" 17.	Sudbury	38.91	56.39	4.66= 99.96
" 19.	Gap Mine, Pa	38.59	55.82	5.59=100.

Demonstration.

Now it is obvious that any replacement of iron by nickel must take place by whole molecules weighing respectively 58.6 for Ni and 55.9 for Fe. Hence for every Ni molecule in mineral No. 14 of the above list there must be $(58.6 \div .25) \times (61.84 \div 55.9) = 259.3$ molecules of Fe ; and, in like manner, there must also be $(58.6 \div .25) \times (37.98 \div 32) = 278.2$ molecules of S ; or, in view of the analytical total being a little in excess of 100, we may regard the mineral as consisting of $Ni\ Fe_{259}\ S_{278}$ instead of $Ni\ Fe_{259}\ S_{261}$, as called for by the pyrrohtite theory.

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[1] Reproduced by permission of the writer from the Journal of the American Chemical Society, vol. XIV. No. 10.

Similar calculations in the other cases give the following results :

No. 15.............. $Ni\,Fe_{30.68}\,S_{42.22}$ showing an excess of $S_{9.54}$
" 15a.... ..... $Ni\,Fe_{61.71}\,S_{70.00}$ " " $S_{6.29}$
" 15b .... $Ni\,Fe_{40.24}\,S_{47.69}$ " " $S_{5.45}$
" 20.............. $Ni\,Fe_{28.11}\,S_{33.46}$ " " $S_{3.35}$
" 18........ ..... $Ni\,Fe_{18.77}\,S_{23.34}$ " " $S_{2.57}$
" 17..... .... $Ni\,Fe_{12.635}\,S_{15.24}$ " " $S_{0.605}$
" 19.............. $Ni\,Fe_{10.463}\,S_{12.642}$ " " $S_{0.174}$

In none of these minerals does the formula $(Fe\,Ni)_n\,S_{n+1}$ hold good ; and we therefore have reasonable ground for declaring that the constitution of nickeliferous pyrrhotite is *not* represented by this time-honored but somewhat superficial generalization.

Relation of sulphur to nickel in pyrrhotite.

It will be noticed that the excess of sulphur bears some relation to the percentage of nickel ; the lower the nickel contents the greater being the surplus of sulphur, and vice versa. This necessarily follows from the great size of the compound molecule when the percentage of nickel is small. If however we investigate the proportion borne by the sulphur to the total metal, we shall find a tendency to constancy rather than to variation, as is shown in the following table :

Percentage of nickel.	Proportion of S Molecules in Excess of $n+1$ to		
	Ni Molecules.	Fe Molecules.	Ni+Fe Molecules.
0.25	16.9	.0652	.0649
0.78	9.54	.1182	.1163
1.02	6.29	.1019	.1003
1.53	5.45	.1354	.1322
2.17	3.35	.1192	.1151
3.16	2.57	.1369	.1300
4.66	0.605	.0477	.04421
5.59	0.174	.0166	.01517

This suggests that the constitution of nickeliferous pyrrhotite is polymeric ; an inference which is also supported by the fact that Nos. 17 and 19, containing the high nickel percentages of 4.66 and 5 59, show less than 1 complete molecule of sulphur in excess, and therefore require a multiplication of their several figures. Taken as a whole however the results of analysis are opposed to any assumption of homogeneity of structure.

Physical investigation.

Coming now to physical investigation, we are at once met by a feature that is conclusive against the hypotheses of "replacement" and homogeneity. I allude to the fact that nickeliferous pyrrhotite may be divided into two portions, one of which is magnetic while the other is non-magnetic. This fact has long been known to chemists. In 1879 Habermehl effected a separation of the magnetic from the non-magnetic portions of pyrrhotite for the purpose of obtaining a pure mineral for analysis. In 1890 T. J. McTighe applied magnetic separation in the treatment of the nickeliferous pyrrhotite of Canada ; and in July of this year T. A. Edison applied for a U. S. patent, in respect of virtually the same invention, and filed a specification containing the following statement :

Treatment by magnetic separation.

Edison's "discovery."

"I have discovered that where magnetic pyrites, called 'pyrrhotite,' is nickeliferous, as it usually is to a more or less extent, the nickel is not distributed generally throughout the whole body of the pyrrhotite, but certain crystals are pure pyrrhotite or magnetic pyrites, while other crystals have some of the iron replaced by nickel and sometimes by cobalt, and that the crystals containing the nickel or cobalt are considerably less magnetic than the pure pyrrhotite."

Any statement made by Mr Edison is deserving of respectful attention ; but I believe that gentleman has frequently disclaimed anything beyond a rudimentary knowledge of chemistry and is therefore presumably open to correction in matters belonging to that department of science. Be this however as it may, I am safe in saying that pyrrhotite is rarely found in a crystalline form, and that crystals of nickeliferous pyrrhotite are as yet unrecorded as having been observed. Mr. Edison's mention of "crystals" is probably only a loose way of describing the minute fragments, particles or grains into which the massive pyrrhotite is divided by comminution.

Separation into two distinct nickeliferous minerals.

Again, Mr. Edison speaks of the strongly-magnetic particles as being "pure pyrrhotite," meaning thereby a non-nickeliferous iron sulphide of the general form $Fe_n S_{n+1}$. My own observations do not confirm the statement that nickeliferous pyrrhotite can be magnetically separated into nickeliferous and non-nickeliferous portions. A separation into two very distinct minerals or mineral mixtures is possible, and these contain very distinct percentages of nickel ; but both are nickeliferous. The following results obtained by Mr. C. T. Mixer at the laboratory of the Emmens Metal Company will illustrate this.

Results obtained from Gap and Sudbury ores.

Two samples of nickeliferous pyrrhotite were taken, one from the Gap mine, Lancaster Co., Pa., and the other from a mine near Sudbury, Ontario. These were very finely powdered and then each sample was carefully separated by means of a magnet into three grades, namely, "magnetic," "feebly magnetic" and "non-magnetic." The "magnetic" and "non-magnetic" grades were then analyzed and resulted as follows, after deduction of gangue :

	Ni.	Fe.	S.
Gap magnetic	0.35°/₀	59.97°/₀	39.68°/₀
" non-magnetic	15.59 "	43.00 "	41.41 "
Sudbury magnetic	1.30 "	58.27 "	40.43 "
" non-magnetic..	23.16 "	33.92 "	42.92 "

Treating these figures in the same way as those of the analyses recorded by Dana, we have :

1. Molecular Constitution—

Sudbury magnetic........	$Ni\ Fe_{46.99}\ S_{56.95}$	showing an excess of $S_{7.96}$
" non-magnetic ..	$Ni\ Fe_{1.535}\ S_{3.394}$	" a deficiency of $S_{0.141}$
Gap magnetic............	$Ni\ Fe_{179.6}\ S_{207.6}$	" an excess of $S_{26.}$
" non-magnetic........	$Ni\ Fe_{2.891}\ S_{4.864}$	" a deficiency of $S_{0.027}$

2. Proportion of Excess S to Metal—

Proportion of S molecules in excess of $n+1$ to

Percentage of nickel.	Ni molecules.	Fe molecules.	Ni + Fe molecules..
0.35	26.00	.1448	.1440
1.30	7.96	.1694	.1659
15.59	Slight deficiency of S.		
23.16	" " "		

A comparison of the results here obtained with those from Dana shows conclusively that the magnetic minerals are of the pyrrhotite type, but that the non-magnetic concentrates are of a quite dissimilar constitution ; and as the latter are much higher in nickel than the former it is also clear that the nickel is *not* present as an element replacing iron in pyrrhotite. It is also apparent that the minerals Nos. 17 and 19 of Dana are mixtures of the magnetic and non-magnetic minerals found in the Gap and Sudbury samples examined by Mr. Mixer.

Much additional investigation is needed to determine the true constitution of pyrrhotite and its allied nickel compound. It may be that experiments as to the solvent action of molten ferrous sulphide upon iron disulphide and nickel sulphide will throw the needed light upon the subject. Many geologists are of opinion that the massive pyrrhotites of Canada and other places are the cooled remains of a molten mass; and every parcel of matte produced from a smelter is an object lesson respecting the varying mixtures that are possible under such conditions. Provisionally therefore we may regard the constitution of the minerals under discussion as represented by the following formulæ:

Crystalline pyrrhotite.... .... $n\ (Fe_3\ S_4)$
Amorphous do .... $n\ (FeS).\ x\ (FeS_2)$
Nickeliferous do .... $n\ (FeS.\ x\ FeS_2)\ y\ (NiS)$.

The practical problem of magnetic concentration.

In conclusion it may be well to say a word as to the practical problem of the magnetic concentration of nickeliferous pyrrhotite. The two samples above referred to as examined by Mr. Mixer gave the following results:

1. Division of the total sample:

	Gap.	Sudbury.
Magnetic portion	58.66 per cent.	92.95 per cent.
Feebly magnetic portion..........	6.67	2.09
Non " "	34.67	4.96

2. Division of the total nickel contents:

Magnetic portion	16 25 per cent.	58.01 per cent.
Feebly magnetic portion..........	19.96	7.60
Non " "	63.79	34.39

3. Total gangue in sample:

Gap	41.28 per cent.
Sudbury	10.7

4. Division of the total gangue:

Magnetic portion	25.85 per cent.	75.51 per cent.
Feebly magnetic portion...	7.12	9.07
Non " "	67.03	15 42

5. Percentages of gangue in the portions:

Magnetic portion	18.20 per cent.	8.70 per cent.
Feebly magnetic portion..........	44.00	46.60
Non " "	79.80	33.20

The practical inferences from these figures are as follows:

1. Magnetic separation will give a rich nickel concentrate.
2. An ore with considerable gangue will yield more of its nickel as "concentrate" than will be the case with cleaner ore.
3. The concentrate from clean ore will be of a higher grade than that from ore carrying much gangue.
4. The nickeliferous portion of the mineral is attached to the gangue more firmly than is the non-nickeliferous portion.
5. The nickel is *possibly an essential constituent of the gangue instead of being a constituent of the pyrrhotite.*

This last inference is so opposed to the generally-received teachings that I have instituted a fresh series of investigations with a view to determine its correctness or the reverse. The results shall in due course be communicated to the Society; and, in the meantime, all I can say is that at present they seem to favor the supposition of the gangue being nickeliferous.[2]

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[2] Writing to me under date of April 8 Dr. Emmens says:

"I think that sometime in the course of the present year we shall introduce into Canada the practice of magnetic concentration of nickel ores. We have negotiations pending with some Duluth parties in this direction.

"I am at present investigating the cobalt question and am having some remarkable experiences with the Drury matte. Cobalt appears to be present in quite unusual abundance, and I also find some manganese, together with a new substance which, if not a hitherto unknown allotropic modification of nickel or cobalt, is a new metal."

X.

SOME NEW NICKEL MIENRALS.[1]

By Dr. Stephen H. Emmens of Youngwood, Pennsylvania.

I have of late had occasion to examine numerous samples of ores from the recently developed mining region known as the Sudbury district in the Province of Ontario, Canada, and in the course of such examination I have met with three nickeliferous minerals that appear to be distinct from any species hitherto described.

FOLGERITE.

This is found in the Worthington mine, on the Algoma branch of the Canadian Pacific railroad, about 30 miles southwest of Sudbury. The mineral deposit here opened up is of a character similar to that usually observed in the mines of the district; that is to say, it consists of a mixture of pyrrhotite and chalcopyrite, forming ore masses of approximately lenticular form and of varying magnitude, imbeded in a green stone dyke traversing the Huronian rocks that constitute the chief geological features of the region.

The pyrrhotite is in itself nickeliferous to a greater or less degree in every mine of the district, but at the Worthington mine it is found to be associated with a distinct sulphide (folgerite) carrying a very high percentage of nickel. This sulphide is spoken of by the local miners and newspapers as being millerite, but it differs widely from that species. Its chief characteristics are as follows:

Characteristics of the mineral.

Lustre: Metallic.

Color: Light bronze-yellow in mass, but almost tin-white when broken up into fine grains.

Specific gravity: No determination of the pure mineral has been made, but a fragment associated with adhering pyrrhotite showed a sp. gr. of 4.73.

Hardness: 3 5.

Streak: Grayish black.

Form: Massive with a platy structure. No crystals have as yet been observed.

Fracture irregular: When comminuted the large fragments preserve a platy form while the smaller particles are finely granular. Very brittle.

Heat reaction: When the powdered mineral is heated in a closed tube no sublimate is produced.

Solubility: The mineral dissolves in nitric acid with separation of sulphur and a green solution.

Magnetism: In large fragments the mineral is non-magnetic. In minute grains it is magnetic. The finely triturated powder is non-magnetic.

Microscopic appearances: Under both lens and microscope the powdered mineral appears in the form of shining white grains of irregular form, very distinct from the shining spicules of a light brass-yellow color which constitute the powder of true millerite.

Chemical analysis: The specimens analysed were magnetically separated from the accompanying pyrrhotite and gave the following results:

Analyses

	A.	B.	C.
Nickel	35.20	31.45	29.78
Iron	33.70	31.01	26.89
Sulphur	31.10	37.54	43.33
	100.00	100.00	100.00

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[1] Reprinted with permission of the author from the journal of the American Chemical Society, vol. XIV. No. 7.

Locality of the mineral.

Specimen A consisted of platy fragments, each one of which was tested separately with the magnet. Specimens B and C were separated in the form of a coarse powder from the accompanying pyrrhotite, and probably still contained some adhering particles of that mineral. In the cases of B and C the analysis was conducted by first roasting the mineral and then fusing with potassium bisulphate, followed by solution, peroxidation, precipitation of the iron and electrolytic separation of the nickel, all with the usual precautions. In the case of A the raw mineral was dissolved in aqua regia. The sulphur was estimated by difference; and a check determination (by fusion of the raw mineral with sodium carbonate and nitrate and final precipitation as barium sulphate) for sulphur only, in a fourth sample, gave 34 per cent It may also be mentioned that specimen A came from the Worthington mine, and that B and C were sent to me with the statement that they came from a deposit at the northeast extremity of the Worthington greenstone dyke. This deposit is distant about 1½ miles from the Worthington mine and has recently been explored by the Emmens Metal Company; but when Mr. C. T. Mixer, the chemist of that company, paid a visit of inspection to the workings, the person in charge who had sent me the specimens in question could not point out the place whence he had taken them, and could not show any further occurrence of the mineral *in situ*. It is probable therefore that A, B and C all came from the Worthington mine.

The formula corresponding with the above mentioned analysis is Ni Fe S_2, which corresponds to

Nickel	32.87
Iron	31.30
Sulphur	35.83
	100.00

This composition is between Ni S (millerite) and $\text{Ni Fe}_2\text{ S}_3$ (pentlandite). It is also distinct from that of the "ferriferous polydymite" found at the Vermilion mine, a little to the northeast of the Emmens Company's working, and described by Clarke & Catlett (American Journal of Science, 1889, p. 372), as containing 43.18 per cent. of nickel, 15.47 per cent. of iron and 41.35 per cent of sulphur, and as approximating therefore to the formula $\text{Ni}_3\text{ Fe S}_5$.

I have named this mineral folgerite after Commodore W. M. Folger, the Chief of the Bureau of Ordnance in the U. S. Navy Department, in recognition of that distinguished officer's achievements in the utilization of nickel steel.

BLUEITE.

Localities of the mineral.

This mineral has for some time past puzzled the Sudbury miners, who have locally dubbed it "Jack's Tin." It is found in several mines of that district and notably at the working of the Emmens Metal Company, where it is found associated with niccolite, gersdorffite, pyrrhotite and chalcopyrite in the outcrop of a quartz vein cutting the before-mentioned greenstone dyke.

Characteristics.

The following are the characteristics of the mineral:

Lustre: Metallic, somewhat silky.

Color: Pale olive-gray, inclining to bronze.

Specific gravity: 4.2.

Hardness: 3 to 3.5.

Streak: Black.

Form massive: No crystals have as yet been observed.

Fracture: Sub-conchoidal, irregular. Brittle.

Heat reaction: When the powdered mineral is heated in a closed tube a sublimate of sulphur is produced.

Solubility: The mineral dissolves readily in nitric acid without separation of sulphur and yields a yellow solution.

Magnetism: The mineral is non-magnetic.

Microscopic appearance: Under the lens the powdered mineral appears to be composed of irregular grains of a dull gray color. Under the microscope the color appears a dull grayish black and the particles are seen to be finely granular without any crystalline form.

Chemical analysis:

Nickel	3.5
Iron	38.8
Sulphur (by difference)	52.3
Insoluble	5.4
	100.00

After deduction of the insoluble matter (gangue) the figures for the mineral become

Nickel	3.70
Iron	41.01
Sulphur	55.29
	100.00

The sulphur is probably too high, as owing to the character of the gangue a portion of this latter may have entered into solution.

The formula $Fe_{12}NiS_{26} = (Fe, Ni)S_2$ where $Fe : Ni = 12 : 1$) corresponds with the foregoing analysis, the figures of such formula being:

Formula.

Nickel	3.76
Iron	42.96
Sulphur	53.28
	100.00

The considerable percentage of nickel (a very rare element in pyrite) and the easy solubility in nitric acid without separation of sulphur seem to preclude this mineral from being considered merely as a nickeliferous variety of pyrite or marcasite. I have named it blueite, after Mr. Archibald Blue, late Secretary of the Royal Commission appointed to investigate the Mineral Resources of Ontario, and now Director of the Bureau of Mines of that Province.

WHARTONITE.

Locality and characteristics.

This mineral was brought to me by Mr. C. T. Mixer from a mine situated about seven miles northeast of Sudbury and about two miles from the Blezard mine, worked by the Dominion Mineral Company. It has been known locally as the Shepherd mine, and is of a character similar to the general mines of the district.

The following are the characteristics of the mineral:

Lustre: Metallic.

Color: Bronze-yellow.

Streak: Black.

Form: Cellular; the cavities being lined with minute cubic crystals and the intermediate substance being finely granular. This structure precludes the specific gravity and hardness from being determined with precision. A large piece showed a sp. gr. of 3.73 and a hardness of 4.

Fracture, irregular: Brittle.

Heat reactions: A sublimate of sulphur in a closed tube and fumes of SO_2 in an open tube. A sulphur flame is observed on heating a fragment held in forceps.

Solubility: The mineral is soluble in HNO_3 with separation of sulphur and a greenish yellow solution.

Magnetism: On comminution about 10 per cent. of the mineral is found to be magnetic.

Microscopic appearance: Under both lens and microscope the powdered mineral is seen to consist of grayish black grains of irregular form and finely granular structure, with occasional minute cubic crystals.

Chemical analysis :

Nickel	5.40
Iron	42.90
Sulphur	45.00
Insoluble	4.80
	95.10

After deduction of the gangue these figures give :

Nickel	5.79
Iron	45.98
Sulphur	45.23
	100.00

Magnetic and non-magnetic constituents.

Separate determinations of iron and sulphur were made in the magnetic and non-magnetic constituents respectively with the following results :

	Mag.	Non-Mag.	
Iron	66.55	40.4	plus a little gangue ;
Sulphur	7.00	52.6	

and a qualitative examination showed that the nickel was clearly with the non-magnetic portion.

The inference deducible from these observations is that the mineral is a mixture of a nickel-iron-disulphide with some magnetite ; and taking the proportion of this latter as being 10 per cent. we have for the composition of the other constituent :

Nickel	6.27
Iron	41.44
Sulphur	52.29
	100.00

Formula.

This corresponds to the formula Fe_7NiS_{16} or $(Fe, Ni)S_2$, in which Fe : Ni = 7 : 1, and of which the figures are :

Nickel	6.10
Iron	40.68
Sulphur	53.22
	100.00

It may be that this non-magnetic mineral is in part composed of pyrite, in which case the formula will require modification. The aggregate however is distinguished by its form and nickeliferous character from pyrite and marcasite.

I have named this mineral whartonite after Mr. Joseph Wharton of Camden, N.J., in recognition of that gentleman's eminence as the head of the nickel industry in America.

NICKEL AND NICKEL-IRON SULPHIDES IN GENERAL.

Relations of nickel and nickel-iron sulphides.

For the purpose of indicating the relations of all the known nickel and nickel-iron sulphides to each other, the following table may be found useful :

Name.	Percentage constitution.			Molecular constitution.			
	Ni.	Fe.	S.	Ni S.	NiS_2.	Fe S.	FeS_2.
Millerite	64.72	....	35.28	1	......	......	.. ...
Polydymite	59.47	....	40.53	3	1	......	......
Beyrichite	57.90	....	42.10	2	1	......	......
Ferriferous polydymite	44.92	14.26	40.82	3	......	....	1
Folgerite	32.87	31.30	35.83	1	.. ...	1	......
Pentlandite	22.03	41.95	36.02	1	......	2	......
Horbachite	11.24	42.81	45.95	1	1	1	1
Inverarite	10.44	49.72	39.84	1	. ..	4	1
Whartonite	6.10	40.68	53.22	.....	1	......	7
Blueite	3.76	42.96	53.28	......	1	......	12

It remains to be added that the analyses of the new minerals herein described were made by Mr. C. T. Mixer, and that specimens of folgerite, blueite and whartonite accompany this paper for exhibition to the meeting.

XI.

A PIONEER'S MINING EXPERIENCE ON LAKE SUPERIOR AND LAKE HURON.[1]

By Walter William Palmer, Washington, D.C.

On landing at Quebec from England June 1st, 1848, and presenting letters, Mr. Bonner engaged me to proceed to Mica Bay on the east shore of lake Superior as surveyor to the Quebec Mining Co., and otherwise to assist Mr. Oliver Matthews the mining manager there at £100 per annum, Halifax currency, besides rations and suitable quarters. I wended my way via Montreal, Toronto and Windsor through red hot Canadian politics, and at the Sault found a delightful change in the association for a few days with Prof. Agassiz and a party of Cambridge students awaiting outfit to investigate the zoology of the north shore, and Dr. Charles Jackson and his assistants on their way to prosecute the geological survey of the south shore of lake Superior. Entertainment was found by inspecting the three and four ton masses of native copper from the Cliff mine, awaiting on the wharf for reshipment, and occasional familiar discourses by the professor on natural history and the glacial theory, and by Dr. Jackson on the igneous origin of the native copper of the south shore of lake Superior from its source in the sulphides on the north shore of lake Huron.

From Quebec to the Sault.

Agassiz and Jackson.

MINING ON MICA BAY.

As soon as Prof. Agassiz and his party were despatched Mr. Peter Barboux turned his attention to me and the six miners for Mica Bay, and in due time we were on the way in a bateau and a canoe in charge of Charles Rousseau and a few Indians. We overtook the professor at his camp at Gros Cap, and found that he and his fresh blooded young men had been very attractive to the black flies and mosquitoes. As we made the traverse of Batchawana bay, and they went around it deliberately, they did not appear at Mica Bay until I had some glacial striae to show the professor on his arrival, and had settled down to my duties of seeing the written orders of Mr. Matthews properly executed. My spare time was filled in exploring the location and making a geological map of the same, and keeping up the new working plan of the mine, which employed about forty miners and was under the excellent foremanship of Mr. Joseph Rodda. The surface operations and fifty men were in charge of Mr. Clarke.

Settling down to duties.

Along in the fall our 11-ton sloop, the Sisquette, brought from the Sault John Bonner, the secretary of the company, and his son Charles, a lad of about 11 years, to spend the winter with us; also Mr. David Price of Chili to establish the Chilian method of making copper regulus (by wood).

Laying in a store of provisions.

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[1] WASHINGTON, D.C., 2000 R. street, 23rd Feb., 1893.

To Archibald Blue, Esq., Director of the Bureau of Mines for the Province of Ontario:

DEAR SIR,—I have the honor to enclose you a few notes as far as my memory serves me of my mining experience in Canada on the lakes Superior and Huron, the mines there located being then considered the most important in Canada. With good wishes for the progress of the industry, I remain very truly yours, WALT. WM. PALMER.

Mr. Palmer spent a portion of the past winter in Toronto with members of his family. He called upon me frequently and I persuaded him to furnish for the Report of the Bureau some account of his experiences in the copper mines of Ontario during a period now well-nigh forgotten. In this way the interesting paper which follows had its origin. Mr. Palmer is a native of Devon, England, and received an education there to qualify him for a mining engineer; and since leaving Canada, more than forty years ago, he has been devoting his life successfully to that profession in the United States and Mexico.—A. B.

The sloop was well freighted with provisions, luxuries, medicines, wines and spirits, and various barrels of beer for the hypothetical smelters. John Thompson Newton, the medical man, and Mr. Duffett the storekeeper had previously arrived.

The sloop returned immediately to the Sault to meet the bulk of the winter's provisions, which had been sent later by the propellor from Detroit, but after waiting a sufficient length of time she returned with only a remnant of previous freight and a French Canadian family which had been left at the Sault, and a letter from Mr. Peter Barboux containing the suspicions that the propellor had been lost. The weather was so rough that the sloop had to put into Mamainse harbor with the perishing family, whence a man arrived tattered and torn with the information. A volunteer crew were soon with a fair wind at Mamainse, but we could not return until late next day. A few crackers supplied to the children were meantime all the refreshments at hand. The father, mother and four children died within a few days after they were landed at Mica Bay; the remaining boy, about 11 years of age, was adopted by Mr. Bonner.

A sad episode.

On the Sunday that we buried the parents on a knoll at the head of the village it was bitterly cold and tranquil, and a dark brown pall of evaporization about two fathoms high apparently and close upon the water overlaid the mighty lake. Thence all was clear to the clear and cloudless sky covering the solemn scene.

In hopes that Mr. C. C. Trowbridge had duplicated the order for provisions, late as it was in the season, the sloop was at once dispatched again to the Sault, Mr. Bonner consenting to my joining so that in case of no provisions of ours being there I might scour the Sault for a cargo. We did find the duplicate supply and took all we could of it, worked our way up the river and in the snow and storm espied just before dark Parisian island, and with a heavy and fair wind at dawn the next morning were close by and heading between Mamainse Point and the rock outside. The discharge of an old Hudson bay wall gun brought Clarke and his crew with a whale boat, who took me on board, and the sloop was sent into Mamainse for the winter.[2]

Supplementing the winter's scant store of provisions.

A few days later Mr. Clarke, who was from the Hebrides and had been many years in the Hudson Bay Co's service, full of resources, invited me to join him and his crew of French Canadians to visit an Indian encampment at the mouth of the Montreal river. Taking the necessary salt we sailed up 12 or 14 miles and in a few days scooped out of the mouth of the river a dozen barrels of lake trout; these with about forty visits during the winter to the same and other Indians, with cariboo and other game in exchange for stuff out of the store, supplemented our scant winter's supply of provisions, and with close economy not only carried through 110 souls but also, with the aid of the salt fish and spruce boughs, a cow and a pony. In the spring however some half dozen men were laid up with the scurvy and required medical attention.

The work proceeded with as much earnestness, order, dignity and Sabbath observance as if we had under hand an incipient Calumet and Hecla. Birthdays were celebrated, especially my majority on December 27th, 1848.

Pioneer work on the location.

On my first arrival at Mica Bay, Mr. Matthews had already brought daylight on the surface of the front of the location by an avenue cut south from the head of the village to the lake shore; by a road to the mine about half a mile north; by another avenue felled on the course of the vein west to the lake shore, passing down hill over the two old lake beaches shown by me to Prof. Agassiz and referred to in his treatise on the Zoology of lake Superior. These beaches with the debris frustrated the object that Mr. Matthews had of exposing the back of the vein, which could not be seen until reaching the trappean sandstone of the wash of the beach, and there the vein was seen only obscurely. Soon after Mr. Matthews caused the felling of another avenue, perhaps a half a mile north of the mine, to a brook which debouched into the lake at a greater distance west, laying say four miles of the sinuous coast-line all come-atable from one point to another and surveyable from the interior.

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[2] Mamainse harbor is about six miles south of the open roadstead of Mica Bay.

Exploiting for copper ore by adit and shaft;

The rock in place exposed itself immediately above and emerging from the upper beach gradually ascending in hogback form towards the interior of the location. At an altitude of say 180 feet above the lake and a quarter of a mile from it, an exposure of gray copper sulphide invited exploitation by adit. This work commenced in trap sandstone and continued into sandstone trap (a transition rock), both reddish and rottenish, but periodically strewn with enough of those carrot-shaped and carrot-sized gray sulphides to induce continuance of the work, but at the same time not producing ore enough to pay half the cost of the candle bill. In due time a shaft had to be sunk to give ventilation to the adit, and in the progress of this work the same kind of ore was found. Sinks in the bottom of the adit to depths attainable by windlass also responded in the same unsatisfactory way to all efforts to find the ore in reasonable body, and up to the date of my leaving, on 1st June, 1849, a few bucketsful only had been saved from meantime findings.

but with a sorry showing.

Mr. Palmer returns to Quebec.

On the conclusion of my year's engagement with the company Mr. Matthews at my request kindly furnished me with a boat's crew to take me to the Sault, and in due time, having examined the Bruce on the way down, I presented myself to Mr. Bonner in Quebec, who thoroughly rated me for leaving Mica Bay and abandoning my future prospects. He stated that he had induced the directors since he had been down to increase my salary; also that he had shown my maps to Lord Elgin, who had been pleased to say that they gave him his first idea of a mine, and that his lordship had invited him to dinner, for which dinner he was indebted to me. After chiding me again he invited me to dine with him, which I did at his house on the Plains of Abraham, and with sincere regret I bade this good gentleman goodbye.

Prince's Bay location.

On this visit to Quebec in June, 1849, I met Mr. John Tregoning and some of his men on their way to England, after having spent the preceding winter in the exploitation of the Prince's Bay location, near Fort William. They had with them to show their company in England some beautiful specimens of netted plate work of native silver enclosing crystals of calc spar; but I was given to understand by Mr. Tregoning, who was an invalid, that beyond such specimens occasionally met with nothing of substantial value had been found. They had also suffered from scarcity of provisions. At Mica Bay we had no suspicion that any mining establishment save our own was working on the north shore that winter.

Visitors at Mica Bay.

During the whole year the only visits of note that we received were two calls, one on his way up and one on his return, from Prof. Agassiz and his students; one from Hugh Wilson, an annexationist from Hamilton; and occasionally during the winter from Father Kohler, a missionary among the Indians; and in the spring from Mr. Ballentine, assistant manager of the Hudson Bay Co., on his way home invalided, via Vancouver; and Sir George Simpson with his fleet of canoes on his way to the Pacific.

Agassiz.

The visits of scientific interest were those of Prof. Agassiz, who recognized on the decomposing slates on the south horn of the bay[3] fine examples of glacial striae. Upon his being shown by me the two terraced beaches, 80 and 160 feet respectively above the present one, he declined to give an opinion as to whether the water had receded or the land risen. Fur-

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[3] The north horn is a felspathic promontory, Point aux Mines, on Bayfield's chart.

Michipicoten island.

ther he said that it was an open question, and was highly gratified with the specimens of current fish which we caused to be caught and preserved for him in whiskey, as well as with the results of his expedition since he left us on his way up the lake.

After its expulsion from Mica Bay the Quebec Mining Company turned its attention to Michipicoten and continued operations to the fall of 1853, when the writer met there Mr. Jehu Hitchins, an English expert from London, and with him a director of the company with a view to passing over the same to an English corporation. Failing this the writer caused it to be passed over to Mr. Chauncey Bush, the head of a New York company, who during the next two seasons spent considerable money in exploiting there for native copper and silver.

IN THE EMPLOY OF THE MONTREAL MINING CO.

Officers of the company at Bruce Mines.

After a month's vacation exploring for Edward Thomas Renaud, the seignior of Berthier, I was sent to take charge of the mining department of the Bruce at £225 Halifax currency and quarters, and found there Archibald H. Campbell, the general manager; H. C. Pilgrim, clerk and cashier; Samuel Sedden Walbank, medical man; John Greenfield, purchaser and distributor of all supplies; Captain Wm. Harris, in charge of the general body of surface hands; and Captain Simmons, in charge of the miners and his share of the mechanics. Mr. Davis with a corps of Welsh smelters and masons was building a full set of reverberatory furnaces, six in number. Engineers and mechanics were busy bringing to completion the engine house, crusher and jigging buildings and corresponding machinery. Captain Martin, the ore dresser, in charge of men and boys, was gleaning stray ores from early surface blasts, spalling and prilling and hand-jigging the smalls of the past and current product of the stopes preparatory to crushing and smelting. James Carson, afterwards a famous mining speculator, was building by contract at the south face of the bay a row of frame houses for the miners with families and another row at the west for the accommodation of the smelters.

Life at the Bruce.

The Bruce had steamboat communication and calls from all parts of the lakes, and was a busy place with upwards of six hundred men in active employment; and a pile of Cleveland coal was accumulating which at the close of navigation amounted, less consumption meantime, to five thousand tons; and soon Mr. Acton appeared as custom house officer. The water supply for all purposes was drawn directly from the lake, generally at the end of the plank resting on a stone in front of the respective houses; the wash of the hillside finding its way also into the same reservoir. Vegetable supplies came; potatoes, cabbage, cucumbers, etc., from distant parts; and chiefly from Major Raines, who had two homesteads on St Joseph's island four miles south. A Catholic chapel had been erected for the French, Irish and Germans, and soon after another sacred building was placed at the disposal of the various religious sects; and a minister and also a schoolmaster were provided by the company.

The departments in the hands of energetic men.

As my duties were confined to the superintendence of the mining operations and preparation of the ores for the smelting works, I cannot say anything about the other departments, save that they were all in the hands of energetic men, able and faithful. On requisition, Greenfield supplied material and Harris any extra men. The accounts were rendered to Pilgrim, who paid the pay-rolls, and periodic reports from all were rendered to the general manager, whose spare time was fully occupied in the assay office.

The mine, and how it was worked.

Straight up northerly about a quarter of a mile from the wharf landing, the eastern stope of the mine was open to daylight, which, with a whim shaft 200 fathoms westerly from this point, formed the end limits of all that there existed of the Bruce mines proper.

The intermediate ground formed a serrated trench irregularly excavated by underhand stoping from 15 to 30 feet in depth along the apex of a greenstone ridge about 50 or 60 feet above the level of the lake.

The stopes in the eastern half of the vein exposure and up to where the vein took "horse" and split in two—the apparent main vein making a slight bend to the south—were uninterrupted and generally connected; but those in the western half were interspaced by benches of poorer ground.

The walls were clean and from four to six feet apart, and in the deeper stretches a slight inclination southerly was discernible by the drag of the windlass buckets.

The storms of the previous winter had persuaded Simmons, the mining captain, to house the stopes, and with a large part of his force he had stulled them, filled the gunnies above with refuse and capped the whole with clay from a neighboring bed found near the swamp north.

Five intermediate and nearly equidistant shafts had been reared from the deeper stopes, and the three western ones had their collars raised to about ten feet above the ground for dumps, and were equipped with horse whims, the whim rounds having been correspondingly raised and encased with circles of dry wall of clean massive vein quartz free of ore. The two eastern shafts were not yet below the reach of windlasses.

According to the system of underhand stoping which had been followed from the giving of the first shot in the mine by Colonel Rankin and Captain Harris, and which, in view of the coming demands of the smelting works had for some time to be continued, Simmons had everything in corresponding mining shape before my arrival.

Extent of the workings and number of miners employed.

The central shaft was about 100 feet deep, and already comparatively poor save in crystals of calc spar, some with double terminations.

The other four shafts looked fairly well and averaged at least two tons of 15 per cent. yellow sulphide for each square fathom of vein. The two western shafts were each about 60 feet deep on the vein, or about 70 feet each below their collars. The two eastern shafts were respectively about 40 and 50 feet below their windlasses. The stopes containing four of the shafts occupied the best stretches of the vein.

Simmons' force, now all underground, consisted of about 70 picked men, some at monthly wages but the majority on contract, all either sinking or stoping on ore, not one man being engaged in any dead work underground; and these men occupied two blacksmiths, whose task was to sharpen each 26 dozen cast steel drills per day.

There was no water in the mine, either by seepage or by subterranean springs.

SETTLING A LABOR TROUBLE.

An incipient unpleasantness settled.

The miners anticipated the impending race between the producing capacity of the mine, the crusher and concentrating works and the smelting paraphernalia, and those of them who had been hired in England at monthly wages came in a body and asked to be placed on a footing with the others on contract. By mutual consent the duplicate contracts were put into the office stove, and this just cause for discontent was allayed. The excessive store charges were complained of and remedied so far as they applied to the necessities of life, and a more exact system of measuring the ground was established on the owner's account.

How the Mica Bay venture ended,

Soon after this the last down boat of the season called at the Bruce wharf and had on board the whole of the outfit of Mica Bay. Mr. Bonner explained that they had been invaded and expelled by a horde of Sault half-breeds under the command of Angus McDonald and his friends. This visit enabled us to recoup our losses by cholera so far as numbers could do it, and we increased the force to upwards of 100 men. The boat then with some difficulty relieved herself from the ice which had formed while she lay at the wharf, and proceeded to Penetanguishene with the remaining majority of men, women and children and their effects, to be taken care of in Quebec by the Quebec Mining Company.

how the Bruce came to acquire odd types of mining men,

Some of the men that Mr. Bonner left had from their boyhood been western hap-hazard lead miners, and had never been brought under any rules of contracts. They knew all that was then known on human rights and the dignity of labor, of which our men had never troubled themselves. On the other hand Greenfield had lately brought up 100 Germans from Detroit, and among them were many ex-statesmen and ex college professors who were masters in social science, having graduated in the revolutions of '48. Many of these, with the supposed ex-minister of Wurtemburg at their head, were now engaged in wheeling coal and carrying the buckets of beer and assisting in drinking it with the Welsh smelters, whose liberal supply of beer and whiskey allowed them often during the day and night, in their streaming perspiration, to drink to the prosperity of the Montreal Mining Company.

and how the Captain's tact mastered the men on settling day.

Meantime the Mica Bay men had been good naturedly admittted and absorbed into the contracts, and had deliberately tested the quartz and complained that it was as hard as—well corundum. Whether it was the introduction and mixing a lot of men unacquainted with the ground, or whether it was the sight above them of a horizontal line of equidistant holes which made a square fathom of ground look larger than it ever looked before, was unknown; but soon after close of navigation the superintendent of the mine received some very neatly-written letters intimating that unless contract prices were raised dire personal consequences would be the penalty. The contracts were measured as usual without remark on either side, and on settling day Captain Simmons rang the bell as usual to call up the men. The only thing unusual on that day was that on invitation Mr. Campbell came to see the fine body of one hundred men.

The letters were read and their receipt acknowledged, but the settling of the contracts was suspended, pending the operation of a reward of £500 for the discovery of the writers.

The men made no remark and as quietly received the recommendation to keep the peace and to get from the store a winter's supply of provisions; but in less than a month a compromise was made by all of them taking the Scotch oath protesting innocence in the affair, and taking a contract to extend to the opening of navigation at a slightly reduced price per fathom. Thenceforth they worked during the whole winter in good earnest, and did well indeed in work and wages. Meantime the other departments were uninterrupted.

It is due to this fine body of men to say that they did not strike; that they did not destroy a particle of property; nor did I hear a disrespectful word. No one lost anything by this interruption. The company gained by the reduction in price, and the men gained at least 25 per cent. more wages by having a long stretch of a contract freed from the petty interruptions of monthly measurements. The sum and substance of the whole business was that on the 1st June, 1850, in addition to supplying the reduction works with current ore, Captain Simmons had a much larger accumulation of crude ore on the dump than he had when I arrived at the mine less than a year previously; and this though no improvement had taken place in the mine, and a few points had weakened considerably in depth.

ROLLS, JIGGS AND SMELTING WORKS.

Breaking and repairing the machinery.

The rolls passed the prills through comfortably, but soon corrugated badly on the second class ore, involving repeated passages of the ore and too frequent changes of the shells for the stock in hand of those necessary wearing parts. One night on stopping the engine to key on new shells the frost got into the crown wheel, and on starting up it broke into several pieces. The contracted engine runners congratulated themselves that they had ahead a winter's holiday and a winter's pay, but this was frustrated by Henry Williams and his comrade, two miners, under whose managament a new wheel was moulded. They failed to fill the mould with cast iron from their improvised blast furnace built in a hogshead; but next refining day Mr. Davis was good enough to allow a half dozen men to ladle and fill the mould with refined copper. The wheel weighed 700 pounds, and I was told it did duty for some years afterwards.

Jigging machines.

Captain Martin with his few jigging machines in the confined building for winter operations attached to the engine house could easily take care of all the crop of ore that the crusher sized, and as the vitrified furnace bottoms near by gave way at uncertain periods he had still less trouble in supplying Mr. Davis with all the ore that he could turn into ingots.

A smelting works incident.

Up to May, 1850, the product of the smelting works had failed to respond to the mine estimates or to the quantity of metal that the assays called for, and the coal pile began to look small, so one day on visiting and informing him of these facts Mr. Davis ordered the furnaces drawn and all his hands to leave the building, and I was left alone to lock the doors, which I did and took the keys to Mr. Campbell. There was no defect in principle nor want of skill in the smelting works, which like the concentrating at first started in the face of winter when defects could not be corrected. Another season's work would have brought a more energetic fuel and a more tenacious sand for the furnace bottoms.

WHY THE MINE FAILED.

The vein unbottomed by jasper conglomerate.

But as for the mine, no skill could avert the inevitable. On his visit to the mine in 1848 Mr. Logan had pointed out that the pudding-stone (jasper conglomerate) which bluffs two miles east would unbottom the vein at an average depth of 250 feet, and the vein when he saw it was probably averaging four tons per fathom. Now it is said that Sir William, then Mr. Logan, estimated the ore in sight at 35,000 tons. Probably his data was: The ore exposure at the mine, 216 fathoms; the average depth at which the pudding-stone bed would unbottom the vein, 250 feet; the average value of the exposed face of the ore, four tons per fathom. These factors make nearly 35,000 tons. I have not the least doubt that the ore face averaged when he saw it in 1848 four tons per fathom. These are the only data now attainable to enable us to judge the rate of deterioration with descent. The Report of the Royal Commission, p. 378, says: "the Geological Survey volumes are silent on the enterprise." The concern was private property and the geologists observe corresponding proprieties. But is it reasonable to suppose that when Mr. Logan imparted to the officers at the mine his views on the unbottoming of the vein by this pudding-stone that the Directors of the Company would long remain ignorant of the skeleton? Again all testimony is silent, but from statements of the oldest inhabitants[4] it appears the Bruce and Wellington closed themselves in 1876 by the tapping of a body of water which inundated the mines, and by caving formed a lake of several acres, the level of which is about 25 feet above lake Huron. Mr. Wm. Plummer says "the deepest shaft was 500 feet." It looks as if this tapped the same conglomerate bed which at this depth had resolved itself into quick sand.

CLOSING MISCELLANEOUS NOTES.

Prohibition.

The general good order of the establishment at Bruce Mines was occasionally discredited by excesses which led to Mr. Greenfield's complying with orders to cut a hole in the ice and sink in the bay the stock of liquors. This anticipated remedy was however frustrated by outside parties from the Sault supplying the stuff at St. Joseph's island. Many men took a walk there on the ice and a few never returned alive, and as the lesser of two evils a responsible man was licensed to open a public house. Thenceforth social relations took the normal form of average communities.

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[4] Not in the Royal Commission evidence.

A general exodus,

About the 1st June, 1850, the Hon. James Ferrier with a mining man or two and some smelters arrived, but their progress on the wharf was obstructed by the exodus of nearly all the miners, all the Welsh smelters and many of the German ex statesmen with their effects—their pockets full of money and in a hurry to get off to the Sault by the same boat which brought him from Penetanguishene.

which the head of the mining department joins.

No curling dense black smoke from the proud stack of the smelting works piloted him into the bay, and the other operative works were in suspense pending the bidding adieu by the remaining fourth of the departing three-fourths. The officers were still intact, but when his wrath was cooled and he could proceed with deliberation he began by making short work of myself by passing all my troubles over to my successor, who soon vastly improved the concentrating works ; for either he or his successor, Archelaus Tregoning, had the good fortune to exhume from below the smelting furnaces in every smelting grade an amount equal to 100 tons of fine copper. So I was told by officers who afterwards joined me on the south shore of lake Superior.

Personals.

About these days the writer had the pleasure of meeting Col. Sam. Jarvis, Hon. Wm. Robinson and Sir Casimir Gzowski, then the Government engineer making preliminary survey on the Canadian side ; and also Jacob Houghton, a younger brother of the lamented first geologist of Michigan, surveying for the canal, which important work he soon after commenced and executed in the Potsdam sandstone on the American side of the Sault.

St. Joseph's island and its ancient fauna.

For the purposes of the Bruce Mines, Greenfield opened a limestone quarry on St. Joseph's island. It was profuse in a large breed of trilobites and vertebratæ consisting of fish, some of the latter as large as those of the present day found in the lake. This stone was used for the erection of the engine house and foundations for smelting works.

Rounding up the story.

A visit to the mines at Port Arthur in company with Messrs. Walbank and Pilgrim in 1875, and thence three visits to Silver Islet, a charter of Ambrose Cyrette's tug to the Little Pic, and a railroad passage through the formation of Sudbury in the Fall of 1890, round up all the writer knows about mining in Ontario.

XII.

NEW SOURCES OF PLATINUM.

By Dr. Stephen H. Emmens of Youngwood, Pennsylvania.

At page 270 of the recently published Census volume on Mineral Industries in the United States reference is made to the development of nickeliferous pyrrhotite mines in Canada, and it is remarked that "the impression has gone out that a small amount of platinum might also be obtained from the Canadian matte, but this does not seem to have been the case."

Platiniferous ore in Denison township, Algoma.

That platinum exists in the Algoma mining district of Ontario has been known ever since the discovery of sperrylite at the Vermilion mine on lot 6 of the fourth concession in Denison township. This was found in the gossan of a vein of chalcopyrite, respecting which Dr. Robert Bell reports: "The vein occurs in diorite and is about four feet wide, but without distinct walls or any veinstone except a mixture of the country-rock."

This discovery led me to pay special attention to some mining work that was carried on in the summer of 1892 by the Emmens Metal Company at the Macdonnell mine on lot 12 of the third concession of Denison. This mine is situated on one of the eruptive dykes that characterize the district, and is thus described by Messrs. Ricketts and Banks who inspected the property in August, 1892:

"The surface of the greenstone dyke has been stripped at several places on the property and an inclined shaft sunk 37 feet at an angle of about 45° to the southeast, upon a mineral vein in the diorite near the southeast contact of the dyke, which latter, having a steeper dip southeast, is cut diagonally by the vein. The ore lens has a nearly parallel trend to that of the dyke. The seam or vein of ore at the collar of the shaft is about 6 inches thick; it pinches to about 3 inches at a depth of 20 feet, and then gradually thickens to the bottom of the shaft, where on the southwest side it is 13 inches thick. The vein filling is largely a changed diorite, with some little quartz and felspar, carrying several irregular seams and scattered bunches of chalcopyrite and pyrrhotite with admixture of nickel minerals. In the bottom of the shaft, in the northeast side, the seam has pinched to about an inch, carrying scattered sulphurets. In the hanging wall of the shaft in this locality scattered bunches of sulphurets are exposed. The ore seam where thin has a shaly dioritic filling, with thin seams of quartz and scattered sulphurets."

Analyses of specimens.

Samples of the vein matter were sent to me from time to time, and upon investigation I came to the conclusion that some of the mineral was platiniferous. Accordingly in July, 1892, I selected two specimens, one broken from a quartz seam in the mineral and the other from the graphitic schistose vein-matter which Messrs. Ricketts and Banks term "a shaly dioritic filling," and I sent both of them to Mr. F. P. Dewey of Washington with instructions to examine them for platinum, gold and silver. The following are copies of Mr. Dewey's certificates of assay:

1. Sample of quartz, etc.

Gold	slightest trace.
Silver	0.73 oz. per ton.
Platinum	trace.

2. Sample of graphitic schist.

Gold	slightest trace.
Silver	1.1 oz. per ton.
Platinum	0.53 oz. per ton.

It must be remembered that these assays were made without any concentration of the ore or separation of gangue. As therefore the sample of graphitic schist sent for examination was a large piece, weighing nearly a pound, with very little show of sulphurets or other perceptible ore-matter, it seems almost certain that the concentrates from the same would furnish a platinum ore of commercial percentage. I did not however pursue the matter any further, because the working of the mine was abandoned on receipt of the report of Messrs. Ricketts and Banks who, having examined the property simply as a nickel mine, did not discover the occurrence of platinum.

The Canadian Copper Company's ores as a source of platinum.

Analyses of nickel oxide.

Another source of platinum that has come under my notice is the "nickel oxide" manufactured by the Orford Copper Company from the matte produced by the Canadian Copper Company at Copper Cliff near Sudbury. This matte is the result of smelting nickeliferous pyrrhotite from the Copper Cliff, Evans and Stobie mines, and thus represents an average of the ore from a district some eight miles in length from southwest to northeast. One ton of the "nickel oxide" contains about 75 per cent. (dry weight) of nickel, and as the raw ore does not yield more than about 2½ per cent., each ton of oxide may be regarded as the concentrates from 30 tons of ore. In October, 1892, the Emmens Metal Co. purchased a parcel of some 18 tons of this oxide (representing therefore 540 tons of ore) and when engaged in refining the same I obtained a peculiar residue, which on examination by Mr. Mixer and myself proved to contain platinum in appreciable quantity. I accordingly sent a fair sample of the whole 18 tons of oxide to Mr. F. P. Dewey for analysis and he reported the precious metal contents to be as follows:

Gold	slight trace.
Silver	1.00 oz. per ton.
Platinum	0.25 oz. per ton.

Prospecting for platiniferous ores in the Sudbury district encouraged.

It would appear therefore that some remarkable foundation exists for the impression referred to in the before quoted passage from the Census volume. It would also seem that a careful examination of the pyrrhotite deposits in the Sudbury district should lead to the discovery of small veins of arsenical ores traversing the greenstone dykes, and that these veins will, upon assay, prove to be platiniferous. I base this opinion upon three premises: first, sperrylite is an arsenide of platinum and occurs in one of the said veins; secondly, the vein at the Macdonnell mine in addition to chalcopyrite, folgerite and pyrrhotite, carried niccolite and gersdorffite, which are both arsenical ores; and thirdly, the "nickel oxide" above referred to contained an appreciable percentage of arsenic.

XIII.

LITHOGRAPHIC STONE.

By Dr. C. W. Volney of New York.

I have during the last two years made extensive explorations of the lithographic stone in the county of Hastings, and hereby report on some of the results of my investigations.

Explorations in Hastings county.

I have to state that I could find but little in existing literature useful in distinguishing identification of good lithographic stone. Dana in his Mineralogy says: "Lithographic stone is a very even-grained compact limestone, usually of buff or drab color: as that of Solenhofen." (Fifth ed. p. 679). But of an innumerable variety of limestones, all showing the above characteristics, only very few can be used by the lithographer. Experiencing difficulties in this direction, I collected a number of acknowledged lithographic stones and analyzed them, and the analytical results and observations are contained in my paper read at the Pittsburgh meeting of the American Chemical Society in December, 1892, and an advance sheet from its journal containing the same I enclose for the use of this report. It is as follows:

Scant literature on lithographic stone.

Chemical study of the stone.

'I regret that in preparing this report I cannot give an exhaustive reference to existing literature on this subject; what I have been enabled to consult did not give me the desired information, and in order to obtain material for comparison I analyzed some mineral from Germany. This was of undoubtedly good quality. Lithographic limestone is the product of different geological formations. If it is true that any limestone of fine, even grain can be use in the lithographer's art, it is equally true that such material seems to be very difficult to find, although we have immense tracts of calcareous deposits to select from. Of the various samples of limestone which have been tested for lithographic purposes, many show in outward appearance a very close resemblance in grain and structure to varieties known to be good, but prove nevertheless worthless. To ascertain the real cause a physical examination seems insufficient, and on the other hand the chemical examination, so far as has come under my notice, does not show sufficient grounds for the established distinction. I quote here the analytical results given in the Report of Mineral Resources of the United States, 1893, as follows:

Stone of good quality difficult to find, and appearances are often misleading.

STONE FROM MISSOURI.

Silicates,	31.2
$CaCO_3$,	817.7
$MgCO_3$,	151.0
Fe_2O_3,	0.1
	1000 0

STONE FROM BAVARIA.

Silicates,	44.5
$CaCO_3$,	814.7
$MgCO_3$,	138 3
Fe_2O_3,	2.5
	1000.0

'Nothing here would indicate any practical difference, and as it is reasonably sure that in physical properties, fineness of grain, etc., these stones resembled each other, a distinction for practical use could not be deduced from

Study of qualities by comparison

these analyses. To obtain however material for comparison I procured German stones of undoubted good qualities as lithographic stone, and selected two, one of dark blue and one of light yellow color, with these results :

Analyses of German,

DARK BLUE STONE FROM SOLENHOFEN.

Spec. gravity at 15.5° 2.952.

Insoluble silicate,	2.0000
Organic matter,	0.7200
$CaCO_3$,	90.9341
$MgCO_3$,	3.5710
Soluble silica,	0.5200
Al_2O_3,	0.5840
Fe_2O_3,	0.2360
FeO,	0.1300
Water,	0.4000
	99.951

LIGHT YELLOW STONE FROM SOLENHOFEN.

Spec gravity at 15.5°=2.8388.

Insoluble silicate,	1.8930
Organic matter,	0.1320
Soluble silica,	0.0200
$CaCO_3$,	89.5390
$MgCO_3$,	4.3801
Al_2O_3,	0.1010
Fe_2O_3,	0.3210
FeO,	0.0030
Water,	1.3790
	97.7681

Kentucky,

LIGHT GRAY STONE FROM KENTUCKY.

Spec. gravity at 15.5°=2.99331.

Insoluble silicate,	11.500
Organic matter,	0.400
$CaCO_3$,	73.241
$MgCO_3$,	12.431
Al_2O_3,	1.141
Soluble silica,	
Fe_2O_3,	
Water,	0.935
	99.648

Iowa,

BLUE STONE FROM IOWA.

Spec. gravity at 15.5°=2.8173.

Insoluble silicate,	6.97500
Organic matter,	3.30000
$CaCO_3$,	82.20051
Fe_2O_3,	1.07631
Al_2O_3,	
Soluble silica,	
$MgCO_3$,	4.32703
Water.	0.24001
	98.11886

Missouri,

LIGHT GRAY STONE FROM MISSOURI.

Spec. gravity at 15.5°=2.7558.

Insoluble silicate,	4.300
Organic matter,	1.830
$CaCO_3$,	77.031
$MgCO_3$,	14.271
Fe_2O_3,	2.143
Al_2O_3,	
SiO_2,	
Water,	0.341
	99.916

LIGHT BLUE GRAY STONE FROM CANADA.

Spec. gravity at 15.5°=2.85156.

Insoluble silicate,	3.71200
Organic matter,	0.40910
$CaCO_3$,	89.98900
$MgCO_3$,	2.78932
Al_2O_3 and SiO_2,	0.73101
Fe_2O_3,	0.15302
FeO,	0.10431
Water,	1.25000
	99.13776

and Ontario

DARK BLUE STONE FROM CANADA.

Spec. gravity at 15.5°=2.89104.

Insoluble silicate,	3.6000
Organic matter,	1.2900
$CaCO_3$,	88.0341
$MgCO_3$,	2.5000
Soluble silica,	0.4900
Al_2O_3,	0.5770
Fe_2O_3,	0.3590
FeO,	0.0410
Water,	1.3601
	99.2512

lithographic stones.

Origin of organic matter in the stones.

'I observed that in a number of stones analyzed in drying at 100° a certain amount of organic matter volatilizes and escapes with the moisture contained in the stones. In most cases therefore the quantity of water will be found too high at the expense of organic matter. The latter contains nitrogen and traces of iodine, and is evidently the remnant of cretaceous fossils, and the silica may also originate from these fossils. It is certain that these organic remains cause the difference in the color; in fact they form the coloring matter of these limestones, and its presence does not seem to interfere by any means with the usefulness of the stone in lithographic art. It might be even presumed that the presence of this partially destroyed animal matter may have had some influence on the peculiar precipitation, and under great pressure on the fine and even formation of these peculiar strata. The material collected by me and the work done so far does not justify a final conclusion; but it is probably sufficiently strong to indicate it, and may give an idea for practical tests. In all other respects, with the exception of some stones containing too much silicious matter, the composition varies but little, and the differences are not pronounced enough to impair the quality of the stone for lithographic purposes.

'Whatever the influence may have been of this organic matter on the precipitation of calcium carbonate—holding this and other inorganic substances in suspension, retarding quick precipitation, and thereby assisting in the formation of even grained and dense strata under subsequent pressure—it may be conceded that lithographic stone was formed during or after the destruction of a large and peculiar fauna, like the Jurassic and Silurian limestone periods; and if further analytical work should confirm what my present investigation seems to indicate, that this peculiar coloring matter is an essential feature of good lithographic stone, an identification of the proper material in the original deposits would thereby be greatly facilitated.'

Age of lithographic stone.

Exploiting the Marmora stone.

As already stated, this work was an outcome of my explorations in the lithographic stone districts at Marmora. The dark blue variety of Canadian stone is from a layer about seventy feet below the general surface of the country near Marmora, showing at the borders of Crow lake. Here some fifty feet of the overlying strata have been broken and washed away, not only exposing on the faces the different layers, but also enabling me to reach those underneath to the level of the lake. Of some twenty-seven layers examined by me only one gave encouraging results, and this is the dark blue variety, analyzed by me as above. In the fall of 1891 I removed a number of large

Tests of samples by lithographic experts

Works erected to prove the quality of stone in different layers.

sample stones from these layers and after proper preparation had these tested by lithographic experts. The mass itself proved to be excellent, and some stones of large size showed sufficient freedom from faults and especially from calcspar crystals as to encourage me to further proceedings. Finding that, for a proper and thorough investigation, machinery for cutting the stone was needed, I erected during the summer of 1892 at the quarry on lot 9 in the third concession of Marmora, buildings and machinery, and also derrick, etc., and from September until the end of November sawed and examined a considerable lot of stones from the layers of this quarry. I found layers, which are practically free from faults, especially free from the calcspar crystals, which have made so far all the lithographic stone from this district useless.

An older deposit than the Solenhofen stone, and therefore of greater specific gravity, but an excellent material.

The lithographic stone of this section is a product of a much older geological formation than the Jurassic, and therefore more dense and specifically heavier than the stone from Solenhofen, which is shown by the specific gravities as given above. Its composition compares most favorably with the blue German variety, and the practical tests prove it to be an excellent material for all the different processes employed in the lithographic art and second to none.

Dip of the strata below the level of Crow lake.

A large capacity of supply.

The layers exposed by my quarrying at Crow lake have been disturbed from their original horizontal position and dip at an angle of about 5° in a southerly direction, whereby at a short distance south from the quarry they run below the level of Crow lake and will therefore make quarrying in that direction impossible. The field to the north and northeast however is free to a considerable extent, and shows a large capacity of supply. I succeeded in finding these same layers at another location east of Marmora, and have made arrangements for the working of these deposits in a business-like manner, so that it may be expected that a considerable quantity will be quarried and prepared for the trade during this year.

XIV.

ONTARIO'S MINERALS AT THE WORLD'S FAIR.[1]

By Dr. A. P. Coleman, Professor of Metallurgy and Assaying, School of Practical Science.

The history of the Province founded on its geology.

The history of the Province of Ontario is like that of every other country, largely founded on its geology. The southern part, with its level Palæozoic rocks covered with good soil, one of the most fertile parts of the continent, was naturally first settled with farmers having the virtues but also the defects of their class. The Silurian and Devonian rocks cropping out along rivers and lakes afforded building stone and lime for mortar, but very few other minerals of importance. If we mention gypsum, rock salt at great depths below the surface, petroleum and a few deposits of bog iron ore, we have exhausted the list of minerals economically important in southern Ontario. There is no coal for metallurgical or manufacturing purposes. There are no easily-worked placer mines to tempt her inhabitants into other lines of work. It is not surprising then that Ontario produced a fine, sober-minded, moderately prosperous race of countrymen, progressing quietly but steadily, afraid of hazardous ventures in business, knowing nothing of mines and minerals, and of the fortunes won and lost in them.

The limit of rapid advancement reached by old methods.

New ventures are feared.

The Laurentian and Huronian country in the greater Ontario to the north and west was non-existent to the hard-working man of the south except as a region of barren rocks and muskegs, where you might get some good pine lumber if the fires had not destroyed it, but that was worthless otherwise because you could not farm it. In spite of its immense area Ontario has reached its limit of rapid advancement according to old methods, and yet its people are afraid to venture on new and risky enterprises to develop the riches of the mining country to the north. Many a farmer and villager was dazzled by the gold of the Madoc region years ago, and sank hundreds or thousands of dollars in the vain search for gold. You cannot persuade these men to risk their money again in a Canadian mining enterprise, no matter how legitimate and safe. They have not learned the methods of handling such matters profitably. For some time to come we may expect Americans, Englishmen and everyone else except Canadians to develop and profit by our mineral resources until we have time to learn from them and gather the knowledge and courage to do our own mining and smelting.

The Chicago collection demonstrates the mineral promise of the Province.

If anything could rouse the people of Ontario to the importance of what lies beneath their soil, instead of nearly at its surface, it should be the admirable collection of minerals prepared for the Chicago exhibition. It is to be sure by no means complete nor perfect in spite of the efforts of that enterprising and indefatigable collector, Mr. Boyle, who with the means at his disposal has done wonders; but it is complete enough to show that Ontario is one of the most promising mineral regions in the world. The collection has been formed chiefly to illustrate the economic resources of the Province, and properly enough much more care has been taken to display a complete set of the ores, building stones, etc., than to bring together a full series of the minerals occurring in the Province, whether economically important or not. Nevertheless the mineralogist finds in the collection much that is of interest from the purely scientific side.

Scope of the paper.

In describing the collection the building and ornamental stones will be treated briefly first, the crystallographic collection taken up next, and finally the metals and their ores will receive attention.

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[1] A paper read before the Geological Section of the Canadian Institute in Toronto.

BUILDING AND ORNAMENTAL STONES.

Sandstones.

Sandstones of good quality are represented from several parts of the Province, including several colors, especially gray, brown, red and banded.

Limestones.

Limestones are present in considerable variety, including marls, lithographic stone, impure limestones suitable for hydraulic cement, and dolomitic or magnesian limestones.

Marbles.

Among ornamental stones suited for monuments, pillars, etc., we find quite a variety of stones, often handsome in color. The marbles may be mentioned first, since they are most extensively represented. Marbles proper are exemplified in thoroughly crystalline specimens from the Grenville series of the Laurentian, but not sufficiently fine grained and pure in color to make good statuary marble. Less pure varieties, often hardly at all crystalline and colored with oxides of iron, clayey and bituminous matters, give a wide range of rich and often pleasing tints, uniform, or softly mottled, or boldly marked. Among them are found pinkish and deep salmon-colored stones, white mingled with gray or with green, combinations of brown and green, and dark gray or even black. Many of them take a fine polish and seem free from checks and fissures; and in all probability better samples will be obtained as the quarries reach greater depths below the surface influences of weather and frost.

Serpentine.

With the marbles may be placed the serpentines of varying depths of green, and the mixtures of serpentine and whitish calcite, which display a pleasing set of soft colors.

Granite gneiss and syenite.

Next to the marbles in importance are the granites and related stones, including gneiss and syenite. These have commonly in our Province tones of light or deep flesh red or purplish red, from the prevalent color of the felspar, but gray granite is also exhibited. On the whole they are excellent stones of good color and take a fine polish.

Jasper.

True porphyry scarcely appears in the exhibit, nor are the greenstones represented to any extent; jaspers of fine yellow and dark red tones are shown from Algoma, one under this head being really a red marble. The jasper conglomerate from Algoma with its red pebbles enclosed in white quartzite should make a beautiful ornamental stone, though difficult to work from its hardness.

Gneiss conglomerate.

One of the most curious specimens exhibited is a kind of gneiss-conglomerate, consisting of gneissoid fragments enclosed in a schistose matrix, with varying soft tones of brown, purplish gray and green. This should make a handsome ornamental stone of a unique kind if it occurs in sufficiently large amounts.

THE CRYSTALLOGRAPHIC COLLECTION.

In taking up the crystallographic collection, I shall include such economic minerals as do not come properly under the head of ores, in this respect gaining unity of plan but deviating from the arrangement made by the authorities of the exhibition. The order followed will be that of Dana in his System of Mineralogy.

Graphite.

Graphite is represented from several points in the Grenville series of the Laurentian, sometimes in bands or beds several inches thick, having a foliated structure, at others mixed with pyroxene or magnetite, and still more frequently disseminated as scales through crystalline limestone. The last combination permits the separation of the graphite in a very pure state. The association of graphite beds with the crystalline limestones is very interesting to the geologist, as tending to prove the existence of plants and animals in those remote ages, even if the organic nature of the Eozoon Canadense of the same rocks should be denied. Of the other forms of carbon, diamond has not been found in Ontario, and anthracite only as a rarity in small pockets.

Molybdenite.

Molybdenite comes next in order, most specimens in the usual form of scales and plates very much like graphite, but having a slightly redder metallic lustre. The most interesting specimen is a large crystal from Renfrew county, a hexagonal prism in appearance, or perhaps rather two very sharp pyramids truncated by basal planes. It has much the shape of some mica crystals.

Pyrite.

Pyrite is of course a common mineral in the collection, and forms the usual brass yellow cystals with brilliant metallic lustre. The forms are of the ordinary kinds, cubes, octahedra and pyritohedra, with some globular concretions. Some of the cubes are an inch in diameter. The dimorphic form of iron disulphide, marcasite, occurs in Ontario near Port Arthur in fine specimens. Arsenopyrite, which is grouped with the ores, displays moderately good tin white crystals, isomorphic with marcasite.

Marcasite.

Arsenopyrite.

Of the group of haloid minerals fluorite and halite, or salt, are exhibited. The fluorite has the usual cubic form and handsome green, yellow and purple colors. It is associated with amethyst and with calcite and marcasite in specimens from Port Arthur.

Fluorite.

Halite.

The halite, or salt, cannot be described as a mineral, since it is prepared by the evaporation of brine and is not obtained in the solid form, though beds a hundred or more feet thick exist in the west of the Province.

Quartz.

Quartz occurs in many forms in the collection, massive for metallurgical purposes, as drusy crystals in geodes, and as beautifully clear rock crystals often quite large and presenting the usual prisms, completed by two rhombohedra at one or both ends, with subordinate trapezohedral planes. Some specimens are curiously abnormal and distorted ; others have regularly arranged inclusions of hematite or göthite. As associated minerals we find pyrite, limonite and other oxides of iron, calcite, apatite and mica. Smoky quartz is shown from Sebastopol township, and the beautiful amethysts of Port Arthur are well represented. The latter are often large and show a zonal structure with varying depth of color. The growth by addition of material from without is exquisitely shown by specimens having a strongly colored inner pyramid enclosed in a paler shell, a crystal within a crystal. The splendid purplish violet is however seldom so uniform in distribution as to give stones fit for cutting as gems. With the Port Arthur amethyst we find common quartz, calcite, green fluorite, pyrite, galena and zincblende; some of the specimens making a small cabinet of minerals in themselves. A little chalcedony and specimens of jasper may be mentioned with the quartz No other oxides are included in the crystallographic collection except a specimen of spinel in calcite from Addington county. No examples are to be found in the collection, I believe, of the black spinels, sometimes called Kaladar diamonds, which occur in various townships in the eastern part of the Province as fine octahedral crystals. None of our spinels are transparent enough to serve as gems.

Amethyst, chalcedony and jasper.

Spinel.

Calcite.

Calcite, one of the commonest minerals, is of course represented by numerous specimens with varying forms and colors. Some examples show the scalenohedral forms of dogtooth spar, others the prism ended by one or more rhombohedra, while many specimens of cleavage rhombohedra are shown. Some examples are almost ice clear, like Iceland spar, though none that I have seen are quite flawless enough for optical purposes. It is greatly to be desired that some new deposit of spar perfect enough for Nicol's prisms should be found to replace the failing stores from Iceland. The ordinary white translucent calcite is commonest, but a singular green variety is shown, and there are flesh-colored ones along with apatite from the phosphate regions. As associated minerals we find among others quartz, amethyst, fluorite, pyrite and galena. Few examples of other carbonates, such as dolomite or magnesite, are mentioned in the catalogue, though both I believe occur in Ontario.

Rhodochrosite or manganese spar is shown from McKellar island, near Port Arthur, and described as argentiferous.

Manganese spar.

Orthoclase and microline.

Perthite

Turning to the silicates, we find the potash felspars well represented. Besides large specimens of orthoclase with the characteristic rectangular cleavages and tones of flesh color or purplish gray, there are many examples of microclin, a triclinic form with a peculiar interwoven twin structure. Probably most of the large rough surfaced crystals from Sebastopol township are of this species, rather than orthoclase proper. There are several examples of green microclin, better known as Amazon stone, though not of specially fine color or crystalline form. One of the most beautiful minerals of the group is perthite, so called from the town of that name from its having first been found near there. It is really an intimate intergrowth of orthoclase or microclin with albite, a variety of plagioclase or striated felspar. Some of the polished specimens are of a very handsome deep flesh or orange red color, with yellowish gleams like aventurine or sun stone. This mineral should make pretty stones for sleeve links, brooches, etc.

Graphic granite.

Examples of graphic granite, an intergrowth of felspar with quartz, are common in Ontario, but scarcely represented in the collection.

Labradorite

Of plagioclase proper few specimens are shown, a specimen of labradorite being the only one I find mentioned in the catalogue.

Pyroxene

Pyroxene, or augite, is a very common silicate in the phosphate region, and is represented by numerous pale or dark green or black crystals, some of them very large and fine.

Tremolite and actinolite.

Hornblende, or amphibole of the ordinary dark green kind, is not largely represented, but its fibrous and acicular varieties, tremolite, which is gray or white, and actinolite, which is pale green, are shown as groups of long crystals or masses of radiating fibres. Some specimens might almost be described as asbestos, having slender parallel fibres, which are unfortunately brittle.

Sodalite.

Sodalite is a rare silicate of a blue color like lapis lazuli. Specimens are exhibited from Dungannon township, county of Hastings.

Garnets.

Garnets are very common in Ontario, and many specimens have found their way to the collection. They are chiefly the common dark wine or purplish red variety, almandine, but some rather fine examples of a yellow or brown garnet, probably essonite or grossularite, are shown. It is doubtful if any of our Ontario garnets are of gem value.

Scapolites.

Wilsonite.

The scapolites of the apatite region are of interest. Some are crystals of the usual form with primary and deutero prisms, pyramid and basal planes. They are gray or greenish gray and have a weathered appearance. The variety called wilsonite, which has a pretty rosy or pale purplish red hue, is found so far as I am aware only in the Ottawa valley, where it occurs in large masses, showing rectangular cleavage but not a definite crystal form. It received its name from Dr. Wilson of Perth, its discoverer.

Vesuvianite.

Vesuvianite comes from the Ottawa valley also, as brown crystals showing prismatic and pyramidal forms, sometimes with bright polished planes.

Zircon.

The zircons of Ontario are justly celebrated for size and beauty. Their crystals are frequently an inch square and have sharp, polished planes of a square prism and three pyramids. Splendid examples of geniculated twins, which are rarely found elsewhere, come from Sebastopol township. A very good example is to be seen in the collection. The colors are various tones of brown, wine color and reddish violet or lavender, and they often have a fine fire and lustre, though rarely clear and uniform enough to be cut as gems. These zircons are associated with felspar, hornblende, pyroxene and scapolite. It is perhaps worthy of mention that many of our granites and other rocks contain beautiful zircon crystals of microscopic size.

Cyanite and prehnite.

Cyanite is found as bluish blade-like crystals in the phosphate and other regions.

Prehnite comes next in the list with a specimen from the north shore of lake Superior.

Tourmaline.

Tourmaline is common in our rocks as the black variety, schorl. Specimens in the exhibition show the usual triangular striated prisms with rhombohedral terminations showing hemimorphy. One specimen consists of slender radiating dark gray prisms. None of our tourmalines are transparent enough to furnish gem stones.

Micas.

Muscovite.

Phlogopite.

Among the most interesting Ontario minerals are the micas, which include muscovite or potash mica, phlogopite or magnesium mica, and biotite or magnesium iron mica. They all crystallize as prisms of the monoclinic system with a nearly hexagonal outline, and have an exceedingly perfect basal cleavage, so that they may be split into elastic plates much thinner than a sheet of paper. Muscovite specimens are comparatively few. They are much more transparent than the other species and yellowish, or in one example green in color. A specimen of yellowish muscovite contains innumerable brown or sometimes red plates of some other mineral between its cleavage plates. Phlogopite, the best represented species, forms one crystal weighing 400 lb., and affords plates half a square yard in area. This mica is amber brown in thin plates and dark brown or black in thicker specimens. Its use in stove windows and as an insulator for electrical machinery make it a very valuable product. Phlogopite occurs almost regularly in association with apatite and its accompanying minerals.

Asbestos.

Serpentine belongs to the same group of minerals as mica, and though it has been referred to under the ornamental stones the fibrous variety chrysotile, or asbestos, as it is generally called, may be mentioned here. This fibrous variety occurs as veins in massive serpentine, the fibres being really minute prisms arranged across the vein. Their fineness and flexibility are the most striking feature of the mineral, enabling them to be teased out and spun like silk or cotton. The greater part of the world's supply of asbestos now comes from the Province of Quebec, where the veins may be two or three inches wide and of a beautiful green silky lustre. The specimens sent to the exhibit from Marmora have not so pretty a color, but show veins almost an inch wide and with every appearance of good quality. If it should be found in large quantities, Ontario may divide the market with Quebec and Italy.

Talc.

Talc belongs to the same group of silicates, and forms pale green foliated masses with a pearly lustre and greasy feeling under the finger. Excellent examples of talc are found in the collection, as well as of steatite or soapstone, an amorphous variety.

Kaolin.

Kaolin comes next in order, examples of the pure white material having been brought by Mr. Borron from the Missinaibi river, near the sea coast of Ontario on Hudson bay. As pure white quartz sand is found in the same region, porcelain may yet be manufactured and another Sevres rise on the shores of Hudson bay.

Titanite or sphene.

The titanites or sphenes of Ontario are celebrated in museums, and excellent examples of all sizes up to portions of a 60 lb. crystal are to be found in the collection. The smaller crystals are often beautifully perfect with brightly lustrous planes. Some are twins. The colors are various tones of brown, sometimes with a fine yellow gleam. They come mostly from the apatite region and are associated with the same minerals.

Apatite.

Apatite is perhaps the best known mineral of the Ottawa valley, specimens of its enormous crystals being found in all the important museums of the world. These crystals are not nearly so rich in planes as the small transparent specimens from the Alps, having as a rule only the prism and pyramid, though a deutero prism and the basal planes are sometimes added. Crystals from calcite often show gleaming polished surfaces, but generally have the edges rounded as though by melting or the action of a solvent. At times calcite fills holes or forms pebble-like inclusions in the crystals. The color is usually some tone of sea green or brown, though deep flesh red, purplish red and even black occur. The Canadian apatites are fluor-apatites, containing about 3½ per cent. fluorine. They are probably as pure phosphates as exist in nature, containing from 70 to 95 per cent. phosphate of lime, but the easily handled Florida phosphates form such serious rivals that comparatively little mining is now being done. Our apatite is associated usually with calcite, often of a fine flesh color, greenish pyroxene, scapolite and wilsonite

Barite and celestite.

Of the sulphates, there are numerous specimens. Barite is shown as fine tabular crystals, and as white masses, the latter from near Port Arthur Celestite, strontium sulphate, occurs in our Province as large, transparent crystals from the limestone near Kingston, as deep salmon colored masses of plate-like crystals from the Credit valley, and as radiating masses of prisms from Addington.

Gypsum.

Gypsum occurs in southwestern Ontario, and also in the Moose river region to the north as selenite in large cleavage sheets or as massive crystalline varieties.

In concluding this rapid survey of the crystallographic collection it is worth while perhaps to note the absence of some groups of minerals, such as the minerals containing rare elements found in the phosphate and pegmatite veins of Norway, which in many respects are very like those of the Ottawa valley. Do these minerals not occur in Ontario, or have they simply not been carefully looked for ?

Absence of some groups.

The absence of true gems from the list is rather surprising, though of course the gathering of mere rarities and curiosities was not intended in forming the collection

Turning up Kunz on Gems and Precious Stones, I find mention of twenty-eight Ontario minerals that might be used as semi-precious stones, but none of true gems. Beside those that have been referred to in the previous notes, I find corundum as red and blue crystals in limestone from Burgess, pale green crystals of beryl from Rainy river, yellow tourmaline from Ross, agate from Michipicoten island, epidote and green prehnite from lake Superior, the moonstone or albite with bluish opalescence from Bathurst and Burleigh ; pyrite, scapolite, ilvaite, zonochlorite and thompsonite. The emerald, ruby, precious opal and diamond seem not to occur in our Province.

NATIVE METALS AND ORES.

Tin.

Bismuth and antimony.

All the important metals are found in Ontario, though not always in appreciable amount. Tin has I believe hitherto been observed only in minute quantities as cassiterite in connection with the platinum ore of the Vermilion mine ; and bismuth chiefly in a few rare minerals or in specks of the native metal from Pierre Plat, lake Superior. Antimony too is rare, though stibnite has been found in Marmora in Hastings, and Sheffield in Addington county. Mr. Dewar's analysis of an obscure mineral from Barrie township shows 20 per cent. of antimony.

Platinum.

Sperrylite.

Platinum exists in small quantities in the Vermilion mine as the arsenide, sperrylite, but perhaps not in workable amounts. Up to the present the world's supply of platinum has come mostly as nuggets and dust from Russian placer mines ; and as it is a valuable and costly metal, the discovery of workable deposits of its ore would be of great interest. Sperrylite is a tin white arsenide of platinum ($PtAs_2$), apparently isomorphic with pyrite. It has a brilliant metallic lustre, a hardness almost equal to quartz and the high specific gravity of 10.6. It contains besides platinum and arsenic traces of rhodium, palladium, iron and antimony, with some oxide of tin, the latter probably an impurity. It occurs with gold ores, pyrite, chalcopyrite and pyrrhotite.

Zinc and lead.

Two of the commoner metals, zinc and lead, occur in large deposits in Ontario, but at present are not mined or only in small quantities. Zinc is found chiefly if not wholly as the sulphide, sphalerite or zinc blende, on the north shore of Lake Superior, in veins from 2 to 16 feet wide. Lead also is found as the sulphide galena in several parts of the Province, and has been mined north of Kingston and smelted at that city.

Manganese is found in pyrolusite, a specimen of which is in the collection.

Manganese.
Iron ores.
Magnetite.
Hematite.
Limonite.
A rare occurrence.

The most valuable and yet the cheapest metal of all, iron, occurs in inexhaustible quantities in our Province, chiefly in the ores, magnetite, hematite and limonite. Magnetite containing 65 per cent. iron with only traces of sulphur and phosphorus, declared to be equal to the best Swedish ore, is found in Belmont, Lavant and other townships toward the east of the Province, and also in the west at the Atik-okan range. In Marmora a porous, weathered variety is a strong natural magnet and readily attracts small pieces of iron. Its magnetism has no doubt been induced by the earth's magnetism. Hematite, massive, specular, micaceous, etc , has been found of good quality at various points in the Ottawa valley and west of Port Arthur. Limonite or bog ore occurs at Snowdon and various other localities in the Province. It is the only metalliferous mineral of importance found in the southwest peninsula of Ontario. Both hematite and limonite occur in ocherous varieties adapted to make mineral paints of yellow, red and brown shades. Siderites and clay iron ores do not appear to occur in Ontario in any large amount. It is greatly to be regretted that at present, with its immense stores of excellent ore, the Province mines little or none and smelts no iron, although iron was smelted at Marmora and other points in Ontario many years ago, and first class charcoal iron is now being produced at Radnor Forges in Quebec with no better ores or fuel. The occurrence of metallic iron in very peculiar concretionary globules at St. Joseph's island, lake Huron, has been described by Dr. Hoffman. No similar occurrence is known in other parts of the world.

Silver ores.
Native silver.
Argentite.
Animikite, Macfarlanite and Huntilite.
A curious Barrie mineral.

With the exception of argentiferous galena, the silver ores of Ontario are chiefly from the Animikie rocks near Port Arthur. Native silver occurs sometimes in large quantities in the mines about Port Arthur, and very handsome specimens have reached the collection, including white or yellowish plates and wire associated with white quartz, amethyst, purple fluorite, calcite, barite and such metallic minerals as argentite, blende, galena, pyrite and chalcopyrite. Fine octahedral crystals of silver have been obtained near Port Arthur. Argentite or silver glance, the black sulphide, occurs as commonly as silver itself and in much the same forms, plates, wire, and also as apparently amorphous masses. I am not aware that crystals have ever been observed in Canada. A specimen of animikite, a compound of antimony and silver (Ag_9 sb), associated with manganese spar, comes from the famous Silver Islet mine. The other two little known related minerals, macfarlanite and huntilite (a silver arsenide) from the same mine are not mentioned in the catalogue. The curious mineral from Barrie township in Frontenac county, analysed by Mr. Dewar and found to contain among other things 1 per cent. of silver and over 40 per cent. of copper, may be mentioned here. Whether it is a mixture of minerals or a definite compound deserving a name for itself one can hardly say at present.

Gold ores.

Native gold, which is of course the most important source of the metal, is quite widely spread, especially in the Huronian rocks of the Province. Specimens associated in the usual way with quartz, oxides of iron and pyrite are found at many points, especially in the Madoc and Marmora region, the Sudbury region and Lake-of-the-Woods. Curious specimens of gold without quartz in green chloritic or hornblendic schist come from lake Wahnapitae. A very refractory ore of gold, arsenopyrite or mispickel, once mined in large quantities near Deloro, is well represented in the collection, and there is a specimen of a rare telluride ore, sylvanite (Au Ag Te sb Pb), from the Huronian mine, Moss township, west of Port Arthur. About the only mine in regular operation in the Province seems to be the Belmont mine, worked by the South African Mining Company near Marmora, though one hears of the Sultana and other mines on Lake-of-the-Woods, of the Ophir mine in Galbraith township, the Vermilion and other mines that promise more or less well. It is rather surprising to find no placer mining region in the Province, though perhaps all deposits of this sort were swept away or buried by the ice of the glacial epoch.

Copper ores.
Chalcopyrite.
Malachite, azurite and cuprite.

Copper ores are widely found in the Huronian and immediately overlying rocks, including considerable quantities of native copper in irregular masses and plates associated with calcite, prehnite and laumontite. This native copper from Mamainse and other points north of lake Superior is precisely like specimens from the famous Michigan copper mining region to the south. Native silver is sometimes found welded to the copper but not alloyed with it, which proves that the metals were deposited from solutions and not in a state of fusion. The commonest copper mineral is chalcopyrite or copper pyrites, which is found in great quantities with pyrrhotite in the nickel region. Other sulphides represented in the collection are erubescite or bornite, well known for its peacock colors, and chalcocite or copperglance. The carbonates, malachite which is green and azurite which is blue, occur only sparingly. Cuprite, the red oxide (Cu_2O), appears associated with some specimens of native copper as small but brilliant crystals. At the present time none of these ores are being worked except incidentally in the production of nickel.

Nickel ores.
Pyrrhotite.
Gersdorffite.
Niccolite.
Blueite.

A large part of the world's supply of nickel is now produced in the Sudbury region, the only rival which Ontario has in this respect being the French colony of New Caledonia in Australasia. On this account the nickel ores of the Province have a special interest. Pyrrhotite, a bronze-colored magnetic sulphide of iron (Fe_6S_7 or Fe_nS_{n+1}) is by all means the most important of these ores, though it contains only two or three or at most a few per cent. of the metal, since it is found in enormous masses. This ore seems regularly connected with eruptions of diorite, diabase or gabbro in or beside Huronian rocks. It is not limited to the Sudbury region, since specimens come from near Rat Portage also. Analysis of Sudbury pyrrhotites prove them to be on the whole much richer in nickel than the same mineral from other parts of the world. So far as I am aware, no crystals of the mineral have been found in Ontario, although it is present in such vast deposits. In other regions tabular hexagonal crystals have been found as a rarity. Comparatively few nickel minerals proper occur in the Sudbury region, niccolite, gersdorffite and three newly-discovered minerals appearing to complete the list. Millerite was reported from the region, but the mineral was probably incorrectly named, since it formed only crystalline masses with a tabular cleavage, quite unlike the slender brass-yellow needles and radiating structures found in millerite from other parts of the world. The specimens which I have seen are probably folgerite. Gersdorffite, a sulph-arsenide of nickel ($NiAsS$), occurs as silver white or steel gray octahedra in niccolite and pyrrhotite from the Gersdorffite mine not far from Sudbury. It is very rich in nickel, but its amount is insignificant. Niccolite, sometimes spelt nickelite or nickeline, the arsenide ($NiAs$) is pale copper red in color when untarnished, and the richest ore of nickel found in our region (43.9 per cent.) It occurs with the previous minerals at the Gersdorffite mine. Three interesting new minerals have been described within the past year by Dr. Stephen Emmens, president of the Emmens Metal Co., of Youngwood, Pennsylvania. Folgerite (formerly called millerite) is a sulphide of iron and nickel ($NiFeS_2$), light bronze yellow, massive, with a platy structure, non-magnetic. The specimens come from the Worthington mine and form a very rich ore of nickel (Ni 31.45 per cent) Blueite (named for the efficient Director of the Ontario Bureau of Mines) is pale olive gray inclining to bronze in color and non-magnetic. It is probably a mixture of nickel and iron bisulphides (NiS_2 FeS_2) with 3.7 per cent. nickel.

Whartonite is bronze yellow and cellular in structure, only partly magnetic, and contains 5.79 per cent. nickel with the formula $NiS_2\ 7FeS_2$. It is possibly not an independent mineral, but a mixture. It is rather singular that none of the green silicate ores of nickel such as garnierite, the chief ore in New Caledonia, or genthite, formerly an important ore in the United States, have been found in any amount in Ontario, though the latter occurs on Michipicoten island. Another point worthy of remark is the very small proportion of cobalt found in our nickel ores, usually only a trace, while in Europe cobalt ores almost regularly accompany those of nickel.

Fossil Fuels.

Peat, lignite and petroleum

A brief reference should be made to the fossil fuels displayed in the collection, though these are comparatively unimportant. They include peat and lignite. The last is a woody brown coal like some mined in Europe. If large seams of it are proved to exist in the Moose river region the fuel question for that part of the Province is solved, but as it is found only in superficial deposits widespread beds are scarcely to be looked for. Our supply of petroleum is confined chiefly to the county of Lambton, though it is also found in the county of Kent.

A Museum of Minerals.

Species represented in the collection.

I have counted about 70 distinct species of minerals represented in the excellent collection sent to Chicago. In my reading I have found about 150 minerals referred to from Ontario localities, some 70 or 80 of which are not in the collection. Many of these have been found only in minute quantities, and none are of any economic importance, so that the collection represents very fairly and fully the mineral resources of the Province, and will undoubtedly do much good by calling the attention of the world to our undeveloped wealth.

Importance of a Provincial museum.

The Chicago exhibit on its return should be placed in some convenient building in Toronto as the foundation of a Provincial collection worthy of such a territory as ours. To it should be added from time to time new specimens, till all the Ontario minerals are well represented in it.

A good set of foreign minerals should be arranged in the same museum for comparison, and the whole should be open at suitable times to the public so that our own people may learn what a heritage they have and be willing to spend money in developing Canadian mines instead of Mexican ones.

An appendix has been prepared giving a list of all the species of minerals referred to in the literature of the subject as far as examined in the preparation of this paper. A few doubtful ones have an interrogation point after them, and a few others are rather synonyms than distinct species. The authorities referred to in preparing the list have been chiefly the Geological Survey reports, especially Dr. Hoffmann's list, and Prof. Chapman's works.

List of Minerals Found in Ontario.

Actinolite.
Agate, Michipicoten, Thunder bay.
Albite.
Allanite, Hollow lake, S. Muskoka river.
Almandite.
Amazon stone, Sebastopol.
Amethyst, lake Superior.
Amphibole=Hornblende.
Analcite, north shore lake Superior.
Animikite, Silver Islet.
Anthraxolite, lake Superior.
Apatite.
Apophyllite.
Argentite.
Aragonite, lake Superior.
Arsenopyrite, Marmora.
Asbestos (also mountain cork and leather) a variety of hornblende, Beaver mine, etc.
Asphaltum, Lambton Co.
Augite.
Aventurine.
Axinite, boulder, Prescott Co.
Azurite, Batchawana bay and Prince's mine.
Barite, McKellar island.
Beryl, Rainy lake.
Biotite.
Bismuth, native, Hastings Co., etc.
Bismuthinite.
Bismutite.
Blueite.
Bog iron ore.
Bornite, lake Huron.
Bournonite, Marmora and Darling.
Cacoxenite, near Brockville.
Calcite, Lanark, etc.
Cassiterite, Vermilion mine.

Minerals found in Ontario.

Celestite, Kingston, Credit Valley.
Chalcedony, lake Superior.
Chalcopyrite.
Chert.
Chlorite.
Chondrodite, Leeds Co.
Chrysocolla, lake Superior.
Chrysotile.
Copper, native, Mamainse.
Coracite, Mamainse (pitchblende partly altered to gummite).
Corundum, light blue and rose red, Burgess.
Cuprite.
Cyanite.
Datolite, Lacy mine, Loughboro'.
Diallage.
Diopside.
Dog-tooth spar.
Dolomite, Niagara.
Domeykite, Michipicoten island.
Eleolite, drift.
Epidote, Mamainse.
Epsomite, Marmora.
Erythrite, Prince's mine, lake Superior.
Essonite?
Fluorite, lake Superior.
Folgerite.
Galena.
Garnet.
Genthite, Michipicoten.
Gold, native.
Graphite.
Gypsum.
Halite.
Hematite.
Hornblende.
Humboldtine, Kettle Point on black shales.
Huntilite?
Huronite (altered anorthite) near Sudbury.
Hypersthene.
Iceland spar, St. Ignace Island, lake Superior.
Ilmenite?
Ilvaite? Ottawa.
Iron ocher, Grey Co., Simcoe Co., etc.
Isarite, part of black magnetic sands.
Jasper.
Kalinite, near Kaministiquia.
Kaolinite.
Labradorite, lake Huron.
Laumontite, north shore of lake Superior.
Lead, native, Kaministiquia.
Lepidomelane, Marmora.
Lignite.
Limonite.
Macfarlanite? Silver Islet.
Magnetite.
Malachite.
Malacolite or Diopside.
Marcasite.
Martite, Bass lake.
Melanite.
Melanterite, lake Superior and Hastings.
Meneghinite, Marble lake, Frontenac.
Meteoric iron, Madoc.
Microclin.
Millerite?
Molybdenite, Ross.
Molybdite, Ross.
Morenosite, Wallace mine, lake Huron.
Muscovite.
Niccolite, Michipicoten and Sudbury.
Oligoclase, Lanark.
Orthoclase.
Pargasite, Renfrew Co.
Pearl spar Dolomite, in cavities and geodes Niagara formation.
Pectolite, Thunder bay.
Peristerite or albite, Bathurst.
Perthite, North Burgess.
Petalite, Toronto (boulder).
Petroleum.
Phlogopite.
Pitchstone, Michipicoten.
Polydymite, Sudbury.
Prehnite, lake Superior.
Pyrallolite, Ramsay and Rawdon.
Pyrite.
Pyrolusite.
Pyroxene.
Pyrrhotite.
Quartz.
Raphilite.
Rhodochrosite.
Rutile, Madoc.
Sahlite?
Scapolite.
Selenite.
Serpentine.
Siderite, lake Superior.
Silver, native.
Smaltite, McKim.
Soapstone.
Sodalite.
Sperrylite.
Sphalerite.
Spinel.
Spodumene, boulder near Perth.
Stibnite, Marmora, etc.
Stilbite?
Sulphur, native, Clinton.
Sylvanite, lake Superior.
Talc.
Tetrahedrite?
Thompsonite (zeolite, Chap.) Mamainse.
Titanite.
Tourmaline.
Tremolite.
Uraconite, Madoc and Snowdon on iron ores.
Vesuvianite.
Wernerite=Scapolite.
Whartonite.
Wilsonite.
Witherite, Twin Cities mine, lake Superior.
Wolframite, gneiss boulder, lake Couchiching.
Wollastonite, North Burgess, etc.
Zircon.
Zonochlorite, Nipigon bay.

XV.

THE UTILIZATION OF PEAT.

The interest which was noted in the Report of the Bureau for 1891 as having arisen on the question of a possible supply of cheap and efficient peat fuel for Ontario, has been maintained throughout the past year. In the absence of coal the circumstances of the Province are such as to require that all available information should be obtained on the subject, and all the light derivable from the experience of other countries cast upon it, in the hope that such a supply may be forthcoming. Prospects are held out that a manufactured peat fuel will be placed on the market during the present year at a price which will enable it to compete successfully with coal, and it may be that a solution of the problem which has been a perplexing one to experimenters is at hand. The facts given below as to the use of peat at the present moment in various countries of continental Europe encourage the hope that some method may be adopted here by means of which our extensive peat bogs may be made to serve as useful a purpose as those of Germany, Holland or Sweden. The difference between the cost of labor in Germany or Sweden and Ontario, though considerable, is not, it would seem, so great as to make it impossible to produce an article of similar quality here at a comparatively small advance in price In Sweden the cost of producing well-made turf for fuel is placed at $1.04 to $1.30 per ton according to price of labor, this being the principal item of cost. Making the necessary additions for other charges and for the higher price of labor in Ontario, there would appear to be still considerable margin left for profitable production at a selling price much below that of coal. In Germany the average rate of wages paid to men at the Government peat works on the Carolinenhorst moor is said to be $1 to $1.12 per day—a rate inferior, but not markedly so, to wages paid for corresponding work in Ontario. Yet the peat produced there is sold in competition with the plentiful supplies of coal raised from the coal pits of Germany itself, while in Ontario such competition would be with coal burdened with freight charges for a carriage of hundreds of miles, besides the customs duty. National habits and customs may count for something, but adherence to old established ways will hardly of itself explain the vigorous survival of the peat industry in Europe, and when the thrifty Dutch, Germans and Swedes find it to their advantage to burn peat instead of wood or coal, it is worth while for the people of Ontario to consider whether or not they cannot replace some of the imported coal used in their stoves and furnaces with a product of their own neglected peat bogs.

Interest in the subject.

Production in Germany, Holland and Sweden.

Cost of production.

At a meeting of the General Mining Association of Quebec held at Montreal on Friday, 7th April, 1893, the subject of peat was under discussion, two papers being read, one by Dr. R. W. Ells, LL.D, of the Geological Survey of Canada, and the other by Thomas W. Gibson of this Bureau, both of which are here reproduced. Dr. Ells' interesting paper deals with peat and its products, while Mr. Gibson's, it will be observed, treats of peat as a fuel only.

Peat fuel discussed by the Mining Association of Quebec.

THE PEAT INDUSTRY IN CANADA.

By R. W. Ells, LL.D., of the Geological Survey of Canada, Ottawa.

The importance of the peat deposits which are found in all the Provinces of Canada has long been recognized, and a number of attempts have been made from time to time to turn them to profitable account. Some of these have for a brief period given fairly satisfactory results, but all have owing to various causes gradually been abandoned. At present however there appears to be a growing interest in the question of their utilization, and it is to be hoped that profiting by the mistakes and experience of the pioneers in the industry some more practical scheme than has yet been in operation may be devised, so that the manufacture of peat either for fuel or other purposes may be placed on a paying basis.

INTEREST OF ONTARIO AND QUEBEC IN PEAT.

Fuel resources of Ontario and Quebec.

This industry has a more important bearing upon the Provinces of Ontario and Quebec from the fact that while the inhabitants are here largely engaged in manufacturing pursuits requiring a large supply of fuel, it has long been a settled question that in neither of these Provinces can any natural supply of coal be expected. In Ontario this lack of coal for fuel may be to a certain extent met by the use of crude petroleum burned in properly constructed grates, and the experiments already instituted in that direction have shown that for heating and the generation of steam this substance possesses very many admirable qualities. In Quebec however this source of supply appears to be unavailable in so far at least as the researches in the Gaspé district, which may be regarded as our only oil field, have proceeded. Natural gas has also of late years entered the field as a possible competitor in the matter of fuel, more particularly in the Province of Ontario, though wells giving a limited flow of gas have also been bored at different points in the St. Lawrence area east and north of Montreal. This source of supply however does not meet the requirements of the case as satisfactorily as could be desired, owing doubtless to some extent to uncertainty as to its persistence, and also to the fact that it is unsuited to many purposes requiring a solid fuel. The fact also that the nearest available sources of coal fuel in eastern Canada are situated in the Province of Nova Scotia, the nearest of which to Montreal is about 700 miles by rail, while the great areas of Pictou and Cape Breton are still more remote, must also be carefully considered in the discussion of such a question as the utilization of the peat deposits near home. True it is that the adjacent Province of New Brunswick has a very considerable development of carboniferous rocks, and has been quoted by many as a great source of future supply of mineral fuel; but from a careful examination of that country it must be remarked that owing to the thinness of the coal seams, rarely more than twenty to twenty-two inches, and the peculiar soft character of the coal itself which unfits it for much handling, as also for other purposes for which a good coal is now required, the utilization of this fuel must be to a very large extent merely local. The other remaining sources of supply, more especially for Quebec, are the distant coal fields of the British islands, from which during a certain portion of the year fuel can be cheaply brought at a low rate of freight, so cheaply in fact as to enter into close competition with the output of the Nova Scotia mines, and the deposits in the United States from which, owing also to canal transportation, fuel can be laid down at certain seasons almost as cheaply as from the lower Province. Still the fact remains that freight rates, both from Nova Scotia and the Pennsylvania fields, are such as to make the price of coal fuel laid down in the manufacturing cities of Ontario and Quebec so high that many of the manufacturing and mining industries in both these Provinces are seriously hampered owing to the comparatively great expense involved in keeping our steam engines in motion and in producing the power necessary to successfully and cheaply carry on the various industries of the country.

Petroleum.

Natural gas.

Coal of the lower Provinces

and the British islands as sources of supply.

The cost of coal a burden on industries.

FEATURES OF A PEAT INDUSTRY.

Conditions of competition with other fuels.

The value of the peat deposits must however after all be merely a comparative one. If it can be conclusively shown that a peat fuel can be produced possessing let us say 100 heat units, and placed in the markets of Ontario and Quebec at a well defined less rate as regards cost than 100 heat units of coal, taking the coals of Nova Scotia and the United States in ordi nary use as the standard, then it should be apparent that our peat deposits are worthy of attention as an important factor among the manufacturing or power producing agents of the day. To do this however we must first of all consider several very important features of the industry, such as the extent of our peat deposits, the calorific power of well prepared peat fuel, the convenience of handling and the advantages it possesses, if any, over the fuel at present at our disposal, and in addition to this, and this is an especially important item, the cost of its manufacture.

Its value for sanitary purposes,

In the utilization of our peat bogs we must bear in mind the fact that other phases of the question possess an equal if not even a greater present economic value than that of fuel supply. For instance the question of the application of peat to sanitary purposes for the reception and economic disposition of the sewage of our large cities is now being largely considered, and it has been ascertained that in this respect no substance yet known possesses presumably greater or more valuable properties than the produce of our peat bogs, so long regarded as practically valueless. Further, a comparatively new industry has come into prominence in connection with these deposits, which in Holland and elsewhere has already reached a very extensive development, and which should also permit handsome returns on capital in this country, viz., the manufacture of moss litter. This material from its great absorbent properties has been found to surpass all other substances in the utilization of stable waste, and for promoting the comfort and cleanliness and as a consequence the health of all animals there kept. So great is the importance of this industry, as yet comparatively unknown in Canada, that the peat bogs of Holland are now supplying the markets of London and New York with this prepared moss litter, with a demand apparently unlimited and at a price quoted in the London market of 21 to 26 shillings per ton according to quality, which should furnish highly remunerative results.

and for litter.

Peat Deposits of Ontario and Quebec.

Early investigations by the Geological Survey.

In the Report of the Geological Survey for 1845-46 attention was directed to the Canadian peat deposits, and the results of the investigation in this subject of Dr. T. Sterry Hunt appeared in subsequent reports. Among these of special importance are the articles in the Geology of Canada, 1863, and in the report of 1866. In the pamphlet prepared for the Paris Exhibition, 1878, further information is presented, more particularly relating to the trials carried on with the deposits east of St. John's in connection with the Hodges process, and at St. Hubert in the county of Chambly, at which places very extensive bogs of excellent peat occur. A very considerable quantity of prepared fuel was produced at these places, aggregating in 1875 about 13,000 tons in all, a small amount being used for domestic purposes, while the rest was employed by the Grand Trunk Railway for their locomotives. Changes in the company however appear to have acted unfavorably as to the continuance of this industry, and since that date but little has been done in this direction. A small quantity of prepared peat was also produced about the same time near Pt. Lewis in the county of Huntingdon, as well as at Newtonville near Port Hope, in Ontario. Unfortunately no reliable data as to the cost of manufacture at either of these places are at hand, and no subsequent development appears to have taken place.

Working the peat bogs of Quebec.

While the peat deposits of Quebec and Ontario are known to be very extensive, the greater part of these have hitherto remained untried. Among the best known may be mentioned for the latter Province the vicinity of the Caledonia Springs, lying to the south of the Ottawa in the township of Caledonia, county of Prescott, and certain bogs in Clarence, Cumberland and Gloucester, the latter in the county of Carleton. Of these the nearest the city of Ottawa is the Mer Bleue, which consists of two long peat bogs, separated by a narrow ridge of higher land and comprising in the two an area of

Bogs of eastern Ontario,

not far from 5,000 acres. These bogs were sounded by Mr. James Richardson of the Geological Survey staff and shown to have a depth in places of over twenty feet, the depth elsewhere ranging from five to fifteen feet. Three other large areas from 1,000 to 3,000 acres each occur in the townships of Nepean and Gouldburn adjoining, while other extensive bogs occur in Huntley and Westmeath. The depth of peat in these deposits varies from eight to over fifteen feet. Further south in the direction of Cornwall bogs are found in Osnabruck, Roxburgh and Finch, so that it is easily seen that a practically inexhaustible supply of material is found in the almost immediate vicinity of the Ottawa and St. Lawrence and in close proximity to the leading manufacturing centres. In western Ontario also peat bogs have been noted at many points, as in the vicinity of the Welland canal, and near lake St. Clair, as also in the counties of Simcoe and York, and farther west along the line of the Canadian Pacific Railway north of lake Superior, as well as on the route between that lake and Winnipeg.

and of western Ontario.

Extensive bogs in Quebec.

Inexhaustible supplies also occur in the Province of Quebec, as in Chambly, St. Hubert and in St. Brigide, where works have already been in operation. On the line of railway from Arthabaska to the St. Lawrence, opposite Three Rivers at Bulstrode, a bog was also formerly worked quite extensively, the product as air-dried peat being used on the Grand Trunk railway, as also in Huntingdon, Champlain, Lacolle and Sherrington, where a very thick deposit of excellent peat particularly worthy of notice is found. East of Valleyfield also and in St. Dominique extensive deposits occur ; while on the north side of the St. Lawrence they are known in the townships of Grenville, Harrington, Mille Isles, St. Anne de Plaines, St. Sulpice, and Lavaltrie and St. Maurice. On the lower St. Lawrence peat bogs are found at River Ouelle, Isle Verte, Daquam, Matane, Macnider and other places ; while on the island of Anticosti an immense bog estimated at nearly 200 square miles in extent occurs on the southwest coast, much of which is reported of excellent quality. From this brief enumeration of a few localities it is easily seen that the quantity of this possible fuel in Quebec is also practically unlimited.

ORIGIN OF PEAT BOGS.

How bogs are formed.

Three classes of peat.

Peat bogs are all of vegetable growth, consisting for the most part of the decomposed remains of plants and mosses, chiefly of the genus sphagnum, which have apparently filled up the basins of shallow lakes. The deposits are frequently underlaid by a layer of shell marl, which has constituted the original lake bottom. The peat bog frequently carries a growth of trees, often of tamarac in a stunted condition, with various heath plants, which by the decay both of their stems and rootlets help to swell the organic constituents of the mass. In bogs of a good depth the peat may be divided into three classes, viz : (1) the green living and growing surface, (2) the intermediate zone in which the remains of the plants are well defined, but which is capable of furnishing an excellent peat for certain purposes, and (3) the lower and fully digested material in which traces of organic life are comparatively rare, which possesses a rich black or brown color, and when free from inorganic matter furnishes a fuel of very excellent quality.

Character of peat.

In character also peat varies somewhat owing to the nature of the underlying rocks. Thus moss peats are generally found on rocks nearly free from lime, such as granite or other strata rich in silica, while grassy or sedgy peats are more frequently found in calcareous districts. In the ripest or most thoroughly formed peat the decomposition of the organic matter has reached the last stage, the result being a dark brown or black homogeneous mass, comparatively dense and heavy. This when moist is firm, sticky and coherent like clay, and can be readily cut and moulded into any shape, and when dried it is hard, having on cut or burnished surfaces a lustre like pitch or wax.

DEVELOPMENT OF PEAT BOGS.

Best peat found in the lowest bed.

Upper portion valuable for moss litter.

In the development or exploitation of a peat bog for fuel it will apparently be advisable to make use of that portion which is freest from organic remains, viz., that which occupies the lowest of the third strata just described, and in former experiments upon the large scale possibly it may be found that some of the lack of success which attended these efforts was due to the attempt to utilize an inferior portion rather than that most adapted to the manufacture of the best fuel. In this connection it may be wise to consider also that it is possible now to utilize the upper portion of the bog as well in the preparation of the moss litter, though the only attempt to develop this industrry in Canada so far as I can learn has been in New Brunswick. There several years ago operations were begun on a peat bog about fifteen miles west of St. John, at a place called Musquash. The promoters were capitalists from St. John and St. Stephen, and a brief account of their operations will be found in the report of the Geological Survey, 1889, by Mr. R. Chalmers. No attempt however was made to manufacture a peat fuel, owing presumably to the facilities possessed in this place for obtaining bituminous coal from the adjoining province of Nova Scotia, the freight from the mines in Cumberland county being low. In order to show however what has been attempted in this direction, I may here quote a brief extract from the report just referred to.

Utilizing New Brunswick peat for litter.

"This article, moss litter, is used in stables as bedding for horses, etc., and owners of studs in the principal cities of the United States have been looking for a material of this kind prepared from the peat found on this side of the Atlantic. What they require is a spongy moss, sufficiently light and porous to be an absorbent of the liquids and ammonia which collect in stables, and which after being used in this way would make a fertilizer for gardens, etc. The company having purchased the bog at Musquash are now, 1889, erecting buildings and machinery there for the preparation of the article. They claim that the peat moss found in this locality is well adapted for the purpose intended, and is equally as good as the German moss litter. Hitherto a large amount of time and capital has been spent by the Musquash company in experimenting and testing the suitability of the different grades of peat or boggy material obtained here for the purpose in view, and it has been found that what is about half decayed, i.e., sufficiently so to be changed to a dark color and rendered somewhat short in the fibre without being absolutely brittle, is the best. This kind of peat is not found in the upper or living part, nor yet in the deep-lying rotted material, but between the two, where the mosses and rootlets are partially decomposed and the fibres strong enough to prevent the mass from crumbling to pieces. The chief process in its preparation is that of depriving it of the water, of which it contains from ninety to ninety-five per cent. This is effected partially in the pit by a machine called a plunger. The moss is then brought by tramways into a building and subjected to great pressure by passing between heavy rollers, and lastly the residual moisture is driven off by evaporation, after which it is packed into bales for shipment."

In the attempt to manufacture a compressed peat fuel of the first quality, or even an air-dried product, it would be well therefore to take into careful consideration the question of utilizing this second layer of say four to five feet for the purpose just mentioned, since it should if properly managed prove equally a source of profit as the manufacture of the fuel itself, while it would enable that portion of the bog best adapted for the latter purpose to be more readily and economically operated.

Objects to be aimed at in the preparation of peat for fuel,

Two great drawbacks have hitherto been found in regard to the utilization of peat as fuel on a commercial scale, viz., the great bulk of the air-dried variety, thus requiring great storage facilities as well as excessive charges for transport, and the contained water, which even in the best air-dried qualities reaches 18 to 20 per cent. This contained water must of course greatly and difficulties to be overcome.

diminish the calorific value of the fuel, and it is the practical impossibility hitherto experienced of reducing this great percentage of contained moisture without very considerable expense which has apparently interfered with the successful economic use of the fuel in our manufactories and locomotives. In the matter of contained water air-dried peat ranks on a par with the best qualities of air-dried wood, but possesses this disadvantage that it contains a much greater quantity of ash, and also has a marked tendency to absorb moisture very readily, a feature which it is apparently very difficult to guard against. In the digging of peat also the precaution must also be taken to provide against the action of frost, since if frozen when wet its coherence is destroyed and it becomes useless as an air-dried fuel.

It is evident from a careful examination of the tests already made of our peat deposits that the objections already mentioned in regard to the air-dried product practically exclude it from the market unless for purely local consumption, and the future course of the industry as regards the fuel question must be along the lines of producing cheaply a thoroughly good compressed article.

Quality of the raw material an important consideration.

In this connection due care must first of all, as already suggested, be paid to the quality of the raw material used. For while simple pressure will reduce the peat to a much smaller bulk, if the material is originally light and porous its natural elasticity will tend when once the pressure is removed to restore it to its normal condition. It has also been found in practice hitherto that the machines employed, no doubt in some cases owing to a lack of proper preparation of the raw material before subjecting it to pressure, have failed to thoroughly remove the contained water; and this has of necessity, if a drier article is required, to be removed by the application of artificial heat at a considerably increased expense, the value of the fuel however being found to be greatly increased by this action.

Comparative value as a fuel.

As regards the specific gravity of the peat, this depends principally upon its position in the bog, and when uncompressed ranges from .25 to .9. In deep bogs a first-class peat of dark blackish or brown color and earthy fracture should have a gravity of .6 to .65. In carbon contents it ranges from 51 to 63 per cent. of the organic matter, its quality being due to its density and ripeness. From a series of experiments conducted by Prof. Johnson of the Yale Scientific School, it would appear that weight for weight the ordinary qualities of peat do not differ very greatly from wood for heating purposes. By compression its heating properties are very greatly increased. Thus it was found that while a good peat cut and air-dried had a heating value of .80, the same condensed and containing 10 per cent. of water had a value of 1.48, and made into peat charcoal the value was increased to 1.73. Compared with wood, this value was found to range from .50 for poplar to 1.18 for summer oak. As compared with anthracite, tests made by the Water Department of Brooklyn showed the ratio of peat to this fuel to be as 1 to 2.25, and a table prepared by Prof. Johnson showing the comparative composition and gravity of peat, wood and anthracite is as follows:

	Carbon.	Hyd.	Ox. & Nit.	Ash.	Water.	Sp. Gravity.
Wood	39.6	4.8	34.8	0.8	20.	.75
Compressed peat	47.2	4.9	22.9	5.0	20.	1.20
Anthracite	91.3	2.9	2.8	3.0	...	1.40

VALUE OF COKED PEAT.

Early uses of peat charcoal.

In regard to the manufacture of coke from peat, it may be remarked that its value has been known for many years. Thus we learn that as early as 1727 patents were issued in England for the smelting and manufacture of iron with this fuel, and in the Hartz mountains in Germany peat charcoal was used in metallurgical operations on a large scale in 1735, but it is stated that owing to the novelty of the process and through the agency of certain parties interested in keeping up the price of wood its use for this purpose was discouraged. Coke from simply air-dried peat is found to be too tender for use in the blast furnace, but that from compressed peat was regarded as equally as good for this purpose as that from bituminous coal. The results of its use in the blast furnace are however conflicting as regards its value, this probably being due to differences in the quality of the coke employed. From a number of trials made in Ireland it was held that the quality of peat coke was equal to that of gas coke, while the total cost according to Vignoles' process, in which the carbonization was effected by means of superheated steam, was about two dollars per ton (8s. 4d.) with the price of the raw peat at four shillings. Three tons of peat were required to produce a ton of coke, the expense being reduced very considerably by the utilization of the bye-products such as wax, tar, gas, etc.

Tests in Ireland

Probably in no country has the manufacture of peat fuel and charcoal been more successfully carried on than in France, and in the earlier reports of the Survey some valuable information will be found as the result of the study of the industry by Dr. T. Sterry Hunt at the time of the French exhibition in 1855. Among those who have brought the industry to to a high pitch of perfection may be mentioned Mons. Brughat, and a few extracts from a short pamphlet of his on the subject may here be given. After summing up the various analyses of peat, wood, coal and charcoal he says the calorific power of compressed peat made according to the Challeton process as compared with wood and coal is in round numbers as follows :

and in France.

Brughat's analyses.

Compressed peat, varying in value according to process of manufacture and containing 10 per cent. of water, from	3 to 4
Peat charcoal	4½ to 5
Bituminous coal, first quality	5
Anthracite	9½
Wood charcoal	1 to 1¾
Wood containing 25 per cent. water	¾ to 1½

In a special report by Dr. Harrington of McGill University, prepared in 1871 in connection with the peat deposits of the Province of Prince Edward island, assays were made of several of the peat fuels prepared from the bogs east of Montreal. The samples are from air-dried material and the assays are as follows :

Assays by Dr. Harrington of Quebec peats.

	1	2	mean.
Water (hygroscopic)	14.82	15.10	14.96
Volatile combustible matter	60.10	59.10	59.60
Fixed carbon	21.80	22.60	22.20
Ash	3.28	3.20	3.24

The assays of two samples of Hodges peat which had been kept within doors for a year are also given :

	1	2	mean.
Hygroscopic water	16.80	17.32	17.06
Volatile combustible matter	49.80	51.65	50.725
Fixed carbon	26.90	25.00	25.95
Ash	6.50	6.03	6.265

ECONOMIC ASPECT OF THE QUESTION.

The excellent paper published in the last report of the Bureau of Mines, Ontario, on the subject of peat, sums up very concisely most of the information contained in the several Government reports, and supplements this with a great variety of facts bearing on the general aspect of the question. From this it would appear that the most recent tests with locomotives and stationary boilers do not give as good results as were anticipated, the percentage of

Recent tests may have been made with peat of

Poor quality and containing an excess of water.

power to cost being very considerably lower than that obtained either from the use of bituminous coal or even wood. This would show conclusively that the quality of the peat employed was far from being what it should be judging from the table just quoted, containing presumably an excess of water greater than should be found even in a first-class air-dried peat. It is probable this peat was obtained from a portion of the bog not representing the best quality for fuel purposes, and thus shows that in the attempt to place this industry on a thoroughly satisfactory commercial basis great care must be exercised in the selection of the raw material. As Brughat has pointed out, repeated failures attended the attempts in this direction for some years both in France and Germany, and it has been only by a careful study of all the conditions not only as regards the material itself but the methods of manufacture that he claimed the success which he has at last attained. It seems difficult to realize the statements as to profit given by Brughat as stated in the report of the Ontario Bureau, but the claim he makes that one and a quarter tons of peat coal are equal to one ton of the best English coal for ordinary steam purposes, and for domestic purposes under proper conditions of draft and grate construction the value is equal ton for ton, deserves a careful consideration of the methods by which these results may be obtained by those interested in the furtherance of the industry in Canada. With coal selling at $3 50 to $4 per ton, which may fairly be assumed as the price paid in Quebec and Ontario in many places for even Nova Scotia slack for boiler use, a compressed peat capable of production at half that price should be profitably employed, while for house purposes where the price of bituminous coal reaches $6 and even in Ottawa $8 per ton, a first-class peat fuel should return very handsome profits to the producer.

Conditions of Brughat's success.

The great extent and apparent value of the peat deposits in this country, together with the very large present consumption of coal and the high prices paid therefor, would appear to warrant the most exhaustive series of experiments tending to solve satisfactorily the economic aspect of the question not only in the production of a fuel suitable in every way for domestic and steam purposes, but for employment also in the reduction of our iron ores and for the various other processes concerned with the manufacture of iron and steel. In this connection we may be permitted to quote again from Brughat:

Importance of careful experiments from an economical point of view.

"It is especially in metallurgical works that very great economy results from the use of our peat. We will obtain among other things both iron and steel of better quality than by the employment of either coal or coke from the use of peat, since the coke therefrom contains no sulphur as has been proved by numerous analyses made with the greatest care, as well as by the practical tests conducted in our forges and blast furnaces both in the manufacture of cast steel, cutlery, gun-barrels and in the casting of other metals."

Cost of production.

In a paper of Prof. N. S. Shaler of Harvard University published in the tenth annual report of the U. S. Geological Survey, on certain fresh water deposits in that country, he remarks on the subject of peat that in his opinion a good peat fuel could be produced at a cost of $5 per ton with labor at $1.50 per day. In view of the results already obtained in the attempts to work the Canadian deposits as quoted in the Geology of Canada, 1863, and from the statements as to cost contained in Brughat's treatise, as well as those obtained from the manufacturers of this fuel in Ireland, we believe that a first-class article can be produced in Canada at a much less figure than he mentions. Such a result however will only be obtained by avoiding the mistakes already so often made by those who have attempted the solution of the problem, and by paying due attention to the quality of the material employed as well as to the use of the best appliances for compressing and preparing for market a fuel containing the least possible percentage of ash and moisture, and in this way obtaining results which will place this material more nearly on a par as regards effectiveness with our best quality of bituminous coals.

Conditions of success in establishing a peat industry.

PEAT AS A FUEL.

By Thomas W. Gibson, Bureau of Mines, Toronto.

Uses of fuel classified.

The uses of fuel may be roughly classified under four heads:

1. Domestic purposes, as cooking, heating, etc.
2. The generation of steam for industrial purposes.
3. The smelting of ores and refining of metals.
4. The production of illuminating gas.

OUR SOURCES OF FUEL SUPPLY.

The substances which have hitherto been almost exclusively employed for these purposes in Canada as in most other countries are coal and wood, either in their natural condition or in the form of coke and charcoal.

Petroleum.

The use of petroleum and petroleum products is not unknown in Ontario, particularly in the furnaces of steam boilers, and recent improvements in the method of combustion have rendered this fuel of importance where distance from the source of production does not unduly enhance its cost.

Natural gas.

Natural gas has also begun to be used and is now in employment on a limited scale for manufacturing, domestic and illuminating purposes, but we are exporting for consumption in a foreign country as much as or perhaps more than we use ourselves, and the probability is that when we get ready to make use of it in earnest we shall find the supply very much reduced.

Wood.

Wood as every one knows is becoming scarcer every year, and increasing scarcity brings its natural result—increased prices. In some country districts in Ontario with which I am acquainted the profusion of wood for fuel purposes which not long ago existed is now at an end. Of recent years such wood as maple has brought a higher price in the log than when cut into lengths for fuel, and the consequence is that farmers have sold their maple trees to saw-millers and their tops and branches only to the users of fuel. These of course are inferior to the body of the tree both for domestic and furnace purposes, and in such districts where wood was once the only kind of fuel thought of it is now a question as between wood and coal, with advantage in economy of price in some cases in favor of the latter.

Lignite on the Hudson Bay slope.

Unfortunately we have no coal in Ontario. At least none has yet been found in the southern portion of the Province, though deposits of lignite are known to exist in the far off valleys of the Moose and Abbitibbi rivers on the Hudson Bay slope. The extent and value of these deposits are as yet unknown, as no systematic survey has been made with a view of determining whether or not they could be made available for economic use, but as they appear to occur in the drift it may be doubted whether they are likely to prove sources of important supply to the coal-users of southern Ontario. At any rate they are yet far removed from communication and means of transport, so that were they ever so valuable they must for the present be left out of consideration.

Pythonic prospectors who locate coal beds in Silurian rocks.

It is quite true that everybody does not agree with the geologists, that we are below the coal bearing rocks in Ontario. It is natural to argue thus: We have been favored by Providence so highly in almost every other respect that it is almost inconceivable we should have been neglected in the matter of coal. Consequently we have heard in past years and still occasionally hear of discoveries of coal having been made in various parts of the Province, such as Collingwood, Bowmanville and several other points. Some months ago a very valuable deposit was discovered—just to put the geologists to shame—not more than eight miles from the city of Toronto, and so precious is the bed to its owners that they have not yet been able to bring themselves to part with any portion of it, or even to raise it to the surface. No later than this week the Bureau of Mines was in receipt of a letter from a man who by means of a divining rod of his own construction had located a seam of coal eight feet in thickness in western Ontario, which upon receipt of a suitable bonus from the Government of the Province he was willing to develop. The advisability of granting such a bonus, I need hardly say, remains under the Government's most serious consideration !

Sources of our coal supplies, and aspects of our situation.

But the lack of coal within our own borders leads to serious consequences. The coal we use comes almost wholly from the mines of Pennsylvania and Ohio, and whenever the gentlemen in control of these mines say "Thumbs up !" on the other side, thumbs have to go up on this side also Were there even unrestricted competition among the producers of coal in the United States, we could hope to get it in Ontario at the lowest price for which it could be profitably sold, but rings and monopolies govern the production and sale of this important article, and we are thus entirely within the power of foreign corporations who cannot be reached by Canadian laws, and who have "neither bodies to be kicked nor souls to be damned." Nova Scotia, the only other possible source of supply, has unfortunately been shown by experience to be too far removed from our markets to admit of our drawing upon it for any considerable part of our requirements.

In view then of the increasing scarcity and dearness of wood and of our coal supplies being in a foreign land and the subject of an odious monopoly, we are, it seems to me, in presence of a situation which demands our instant and most careful consideration. How are our private and public interests to be protected ?

Is there Escape from the Situation?

Will electric-y solve the oblem ?

There are those who hold out the hope of escape from the situation by means of electricity, that force which has already done so much and which is to solve every possible problem of transportation, lighting, heating, smelting and power. Fuel is not required, they say, for the generation of electricity where you have sufficient water power, and in the undeveloped rapids and falls of the upland regions of Ontario where the headwaters of the Muskoka, the Madawaska, the Petawawa, the Bonnechere, the Mattawa, the Severn, the Otonabee, the Trent and many other streams take their rise, not to mention the immense potentiality of the falls of Niagara itself, lies the ultimate solution of the fuel question of Ontario. But while the grass grows the steed starves. There are many and great improvements to be made in the generation, transmission and utilization of electric force before these distant sources of power can be made available for the ordinary purposes of every day life, and some greatly superior means of transmitting electricity through long distances especially is required before that form of force can be expected to supersede for all uses the chemical energy evolved by the oxidation of carbon.

Utilization of peat in older countries.

In older countries, where wood has become scarce and coal for various reasons unavailable, recourse has long been had to peat as fuel, both in the ordinary air-dried form and in a manufactured condition after treatment by various processes. In Ireland, Scotland, Germany, France, Russia, Norway, Sweden and every other European country where peat is found—and it occurs in almost every country lying within the temperate zone—a large proportion of the peasantry have for centuries depended almost entirely upon peat for heating and culinary purposes. I do not need to give any description of the ordinary method of cutting and saving peat, which is practically the same in all lands. It is cut with spades or tools of special form into brick-like blocks, which after sufficient exposure to sun and air become dry enough to burn. This is the method employed where a peat bog can be entered upon and dug with safety and convenience. Where the peat occurs as it sometimes does in a pasty or mud-like mass of little consistency, it is dragged or scraped out to firm land, and upon evaporation of the contained water it forms an article of fuel considered even superior to that produced from an ordinary bog. Air dried peat from a good bog, properly cut and saved, is by no means a despicable article of fuel. There are those indeed who have used it in the old lands who do not hesitate to claim for it an equality with either coal or wood. Doubtless however one of its principal advantages to the poorer people of European or other countries is that it can be obtained at an expenditure of little more than their own labor. A family of growing boys with some assistance from the father or even the mother can easily secure a year's fuel at the cost of a few days' or weeks' work. The fact that (as in Scotland) where wages have risen and increased facilities of transport have made coal available, the latter is preferred to peat, shows that on the whole common air-dried peat is not to be compared with coal as a fuel.

MANUFACTURE OF PEAT.

Methods of improving peat for fuel.

By various methods of manufacture however the crude article is very greatly improved and brought more nearly upon an equality with coal. The principal objections to air-dried peat are its bulkiness and the considerable percentage of water which it retains. One ton of coal is the equivalent in evaporative effect of several tons of common air-dried peat, and ordinary specimens of the latter even when considered dry and fit to use contain not less than 25 or 30 per cent. of water. The object of manufacture is therefore to reduce the peat in point of bulk and to free it from water. One method adopted to compass these ends has been tried by means of a great variety of mechanical appliances by inventors on the continent of Europe, in Great Britain and even in the United States. It consists essentially in reducing the peat as taken from the bog by grinding, triturating or macerating machinery to a pasty, pulp-like condition, after which it is spread out upon the surface of the ground, marked off into divisions of suitable size and allowed to dry. Sometimes the peat is moulded or pressed before being dried, sometimes air-dried before being compressed, and in some methods the drying is done by artificial heat. The result, especially when the drying is hastened by artificial means, is a hard dense fuel approaching or equal to coal in specific gravity, and capable of emitting intense heat. The cost however is considerable, and though occasionally especially favorable circumstances have conspired to render the experiment feasible and to enable the manufacture to be continued, sooner or later the expense has risen to a point beyond the returns, and failure has been inevitable.

The difficulty to be overcome.

Peat as it exists in the bog contains 90 per cent. and upwards of water, a large proportion of which it retains with the utmost tenacity, but all or nearly all of which must be got rid of in process of manufacture. To evaporate eight or nine tons of water in order to obtain one ton of fuel would on the face of it seem an impracticable undertaking, hence various plans have been attempted to overcome this difficulty.

Harrowing.

One is, after the living and (for fuel purposes) worthless growth on top of the bog has been removed and the bog drained, to pass a light harrow over the surface, after which the partially dry peat is collected and the process completed.

Pulping.

Compression of the crude peat whether by rollers or powerful presses has also been attempted, but in connection with the pulping process has not proven very successful, as the pulping is done with much more difficulty and requires much heavier machinery when the material is in a partially dry state. Indeed with some stiff, dense peats from the lower portion of deep bogs water has not infrequently to be added in order to effect a reduction to the necessary paste-like condition.

Compressing and drying by artificial heat.

Another system of manufacture is one in which the peat is passed through compressing machinery at the beginning of the operation, and without being pulped or having its original fibre destroyed is dried by artificial heat and by strong pressure formed into blocks, cakes or cylinders of the desired size. The employment of artificial heat of course adds to the cost of the process, but it is doubted by some whether the water contained in the peat can be wholly expelled or even eliminated to the required extent by pressure alone, and experience appears to bear out this view.

Improvement by charring or coking.

Peat is used not only in its ordinary form, but like wood and coal may be carbonized and reduced to coke or charcoal. Containing a percentage of carbon in proportion to its weight intermediate between that of wood and coal, it gives on carbonization a corresponding weight of charcoal. Wood yields about 22 to 27 per cent. of charcoal and coal 75 to 90 per cent., while peat gives about 23 to 35 per cent The condensed peat produced by the pulping process gives a much harder and denser charcoal than the ordinary air-dried article, the charcoal from which is so friable and light that it cannot be used in metallurgical operations. Peat charcoal has this advantage in common with wood charcoal over coke from coal, that it is much freer from impurities, such as sulphur and phosphorus, which exercise so injurious an effect in the smelting or refining of iron. These and other impurities however are not unknown in peat, and their absence or presence is usually dependent upon the constituents of the rocks and soil surrounding the bog from which the peat is taken. The decomposition of gypsiferous or pyritous rocks in the neighborhood of a peat bog would, for example, be sufficient to account for the presence of sulphur in the ashes of peat fuel manufactured from it. A bog in Wales containing copper pyrites was long used for the production of peat which was burned for the sake of the resulting ashes, many thousands of pounds' worth of copper having been extracted therefrom. Peat usually yields more ash from a corresponding weight than wood and about the same as coal, but it varies greatly in this respect with the composition of the bog from which it is taken. Sand, lime and other similar substances are generally found in the ashes of peat, either in chemical combination or mechanical mixture, having in most cases been derived from the surrounding soil.

PROCESSES UNDER WAY.

Slow progress in the manufacture of peat.

As might have been expected, much more effort has been made to produce a good article of peat fuel economically in European countries than in the United States, where there is a comparative abundance of coal. In the latter country about twenty-five or thirty years ago coal was even higher in price than it is at present, and much attention was directed to the utilization of peat, without however any lasting result. In Canada on the other hand the fuel problem has been more pressing, and at various periods processes have been in actual operation for the manufacture of peat fuel for a longer or shorter time. Recent events seem to indicate a revival of the interest in this question, for at the present moment there are three or four processes under way by which their inventors hope to solve the perplexing problem. In the neighborhood of Montreal and elsewhere in the Province of Quebec probably more persistent attempts have been made in this direction than anywhere else in Canada. Nearly thirty years ago Hodges placed his pulping machinery on a scow and manufactured peat at Bulstrode, at we are informed a cost of 92 cents per ton, and large quantities were consumed as fuel for the locomotive engines of the Grand Trunk railway. A somewhat similar process invented by N. Aubin and improved by James Hally was at work for a time under the management of the Valleyfield Peat Company, while David Aikman of Montreal for many years has been experimenting and is still experimenting with the process of manufacture which bears his name. A. A. Dickson of the same city has invented a process somewhat different in principle from any of these, which he believes is now perfected, and which the company he has formed intend to have in operation this coming summer in a bog on the Welland canal, where they have purchased a tract 3,000 acres in extent. I have here specimens of Aikman's, Hally's and Dickson's peat fuels, as well as samples taken by myself from a small bog near Berlin, Ontario. The last named

The Hodges, Aubin-Hally, Aikman and Dickson processes.

sample is of the ordinary air-dried kind, and being taken from the bottom of the bog shows the deposit of shell marl underlying the bed of peat. Specimens of Aikman's and Dickson's manufacture corresponding to these have been submitted to Prof. Ellis of the School of Practical Science, Toronto, for examination. He has tested them in a Thompson calorimeter with the following result:

A calorimeter test of manufactured peats,

	Aikman peat.	Dickson peat.
Moisture.	7.4	10.2
Ash	19.5	2.9
Heating Power	5115 units.	5280 units.

Three samples of standard kinds of bituminous coal were also submitted to Prof. Ellis for purposes of comparison, which gave in heating power as follows:

and bituminous coal.

	Units.
Hocking coal, Ohio	6,820.
Masillon coal, Ohio	7,425.
Reynoldsville coal, Pennsylvania	7,480.
	Mean—7,241.

The heating power is expressed in metric heat units.

It will be seen that the two specimens of peat are nearly alike in heating power, and that in this respect they stand respectively in the relation of 71 and 73 per cent. of the mean value of the samples of coal. The average price of Reynoldsville coal at Toronto, where it is said to have control of the market for heating purposes, is $4.25 per ton, so that on the basis of calorific value alone these peats would appear to be worth about $3 or $3.10 per ton. The percentage of moisture does not materially differ in the two samples, being 7.4 and 10.2 respectively, and it is probable that experience would show the inutility of going to the trouble and expense of reducing the contained water below the smaller of those figures, as on exposure to the atmosphere the absorbent qualities of the peat would doubtless be sufficient to restore the percentage of water to at least this point. The greatest difference between the samples is in the matter of ash, in respect of which there is a marked inequality, one sample showing 19.5 and the other 2.9 per cent. This is of course due entirely to the composition of the bogs from which the samples were made, and has no bearing upon the merits of the processes of manufacture themselves. If the crude peat contain a considerable proportion of incombustible matter no amount of trituration, compression or other subsequent treatment will lessen it, and the plain inference is that in the manufacture of peat fuel only those bogs should be employed which careful experiment shows to be reasonably free from inorganic substances. The proportion of ash contained in the more impure of the two samples, 19.5, is so high as to seriously detract from its value as fuel, and would lead to the conclusion that the bog from which it was made is not well suited for the manfacture of the article.

Comparative merits.

Ash.

PEAT FUEL FOR METALLURGICAL OPERATIONS.

A recent letter from England gives an account of a process by which Mr. J. D. Brunton of London is attempting to utilize the peat of Dartmoor in the production of pig iron from hematite ore, of which abundant supplies exist in that district. He proposes to use by a happy reciprocity the waste gases from the blast furnaces to dry the peat, and the peat, apparently without being charred, to smelt the iron. It is estimated that 200 tons of peat will suffice for a yield of 100 tons of pig iron per week. The cost of iron ore is put at from 3s. to 6s. 6d. per ton, and the cost of the pig iron made under these conditions after ample allowance for contingencies at £2 15s. per ton. If the selling price of the iron be put at only £5 per ton (a low price for charcoal iron) a profit of £2 5s. is expected to be realized. A square mile of the Dartmoor peat ground is said to be sufficient to supply fuel for a make of 100 tons of pig iron per week for 100 years.

A new English process of manufacturing peat for blast furnace fuel.

The application of the hot gaseous products of blast and other furnaces to the dessication of peat is not however original with Mr. Brunton. On the continent of Europe kilns for drying peat have been constructed in which the hot waste-gas of furnaces is driven in through the roof by means of a fan, made to descend through the peat, and thence to pass into a chimney communicating with the interior of the kiln at the bottom by two flues, one on each side. Kilns on this principle are said to have been first introduced by Schlägel into Austrian smelting-works, and extensively adopted, especially in French smelting-works. The distinguished Swedish iron master Gustav Ekman in 1856 erected a peat kiln upon this principle with, it is reported, an entirely favorable result. Ekman heated his kiln with the waste gas of a charcoal finery, which gas after having been used for heating pig iron, the blast of the finery and an annealing furnace, was admitted into the kiln. Kilns constructed on the principle of taking in the hot gas at the top are said to dry the peat more equally and quickly than those in which the gas enters at the bottom.

Peat kilns in Europe.

Utility of peat fuel in metallurgical operations.

Peat and peat charcoal are used to some extent in the smelting and refining of iron in European countries, but where, as in Great Britain, mineral coal and coke are abundant the latter are more generally employed. Dr. Percy, after a somewhat exhaustive review of the subject in his work on Fuel, gives it as his opinion that "by a judicious selection of peat and suitable treatment peat charcoal might, so far as relates to its capability of producing heat, serve as an efficient fuel for metallurgical operations." He adds that "the use of peat charcoal for fuel must in great measure depend upon the cost of its production, inclusive of the cost of the original peat, and its capability of competing in that respect with other fuel, namely, wood-charcoal, certain kinds of coal and coke." The widest field of usefulness for peat in metallurgical processes would appear to be as material for the production of gas for use in the so-called regenerative furnace invented by the brothers Siemens, which has come so largely into use for smelting and refining purposes. To quote Percy again: "Experience on the continent has conclusively shown that peat-charcoal may be used in some metallurgical operations with success; also that peat may be successfully used for the production of gaseous fuel in a gas-producer. Mr. C. W. Siemens indeed has informed me that putting its cost aside he should even *prefer* peat to coal for use in the producers of the regenerative gas-furnace. Now the metallurgical operations to which gaseous fuel has been applied are already numerous, and it seems capable of even much wider application. The drawback in the employment of peat when high temperatures are required, resulting from its containing a large quantity of water, is obviated by converting it into gaseous fuel, and subsequently condensing the moisture contained in the latter. So far therefore as the suitability of peat for metallurgical purposes is concerned, we may not unreasonably conclude that it could be widely substituted for coal with success." Percy goes on to state his conviction that peat can only compete with coal in countries where the cost of production and carriage of peat is relatively very low and the price of coal relatively very high, and that as regards Great Britain circumstances must greatly change before these favorable conditions for utilizing peat are fulfilled.

The situation in Ontario and Quebec.

Percy's conviction as regards Great Britain is doubtless well founded, but the state of things in Ontario and Quebec is vastly different from that in the mother land. The pregnant fact that while there is abundance of coal in England there is none at all here changes the situation entirely, and conclusions which may be justly arrived at in the case of Great Britain are altogether inapplicable in our own. The cost of carriage which in England would be greater upon peat than coal is here decidedly in favor of peat. Our only supplies of coal lying either a long way to the south in another country, or a long way to the east in another Province, the item of freight charges must always be a heavy one and must continue to add largely to the cost of the coal used here, while on the other hand once a really practical and economic system of manufacture was introduced the peat bogs which are found in all quarters of Ontario and Quebec might be made sources of fuel supply to surrounding districts at a minimum cost so far as freight charges are concerned.

PEAT AREAS IN ONTARIO.

There are very large areas of peat in Ontario. Mr. E B. Borron, who has penetrated through the wastes of the Hudson Bay slope, tells us that in his opinion there are 10.000 square miles overlaid with peat from six to twenty feet in depth in that part of the province. In the district between the Ottawa and the St. Lawrence rivers, in the vicinity of lake St. Clair, in Elgin county, in Parry Sound district, in Waterloo county, in Welland county along the Welland canal, in the counties of York and Simcoe, along the line of the Canadian Pacific Railway west of lake Nipissing, and in many other sections of the Province are peat bogs of large area, and were they to become valuable as a result of a perfected process of manufacturing peat fuel the existence of many others would no doubt be revealed.

Localities where peat deposits are found in great abundance.

A storehouse of great value

Peat fuel has been successfully employed for all the purposes for which coal and wood can be used. For some of these purposes it is, owing to its bulk, less adapted than coal, as for instance in steamer and locomotive boilers, where economy of space is a great object, while for others, as we have seen, it is a very efficient substitute. Even in the production of illuminating gas it has been employed with good results, as for example in Dartmoor, England, where the prison at Prince Town is or was lighted with gas made from peat.

In conclusion, I have only to express my conviction that this problem of the utilization of peat for fuel is one of the most important and pressing of the economic questions which are today engaging the attention of the people of Ontario and Quebec. Though the difficulties which lie in the way of its solution have proven themselves to be many and formidable, the ingenuity of man is, I am convinced, equal to the task of overcoming them. I cannot think that the quest after a good cheap peat fuel is the chase of an *ignis fatuus*, but on the contrary I cherish the hope that ere long we shall see a process in successful operation which will utilize our own resources, give us a first-class fuel at a cost below that of coal, and deliver us from the yoke of a foreign monopoly.

when the problem of treatment is solved.

DISCUSSION ON THE PAPERS.

Discussion upon the papers was invited, and Mr. A. A. Dickson, who was present, and whose method of manufacturing compressed peat fuel was described in the Report of the Bureau of Mines for 1891, was asked to speak.

Mr. Dickson said he had little to add to what had already been said, except to say that the company which he had organized had secured a bog on the Welland canal about 3,000 acres in extent, and were having the necessary plant constructed for manufacturing the fuel. The blocks which had been exhibited as of his manufacture were merely small samples. It was the intention of the company to make the fuel in at least two sizes, one in blocks about 3 inches long and 3 inches in diameter for steam generating purposes, and the other for domestic use in blocks about 2 inches in diameter. In his process as perfected the moisture is driven off solely by compression, artificial heat not being required, and not more than 10 per cent. of water is left in the manufactured article. They found the quality of the peat in the Welland bog to be excellent, and the upper portion after the moss is removed to be nearly as good for fuel purposes as the lower, the samples shown having been made from it.

Erecting works to manufacture peat fuel on the Welland canal.

Mr. B. T. A. Bell asked Mr. Dickson at what price he thought he could place his fuel on the market.

Mr. Dickson replied that it would have to be sold at a lower figure than coal. The cost of manufacturing would be about $1.50 per ton.

Resistance to moisture.

Mr. Th. Doucet inquired whether samples of Mr. Dickson's peat such as those exhibited had ever been subjected to water, and with what result.

Mr. Dickson said the peat was proof against moisture under ordinary circumstances, but if immersed in water for some time it would absorb a certain percentage. The samples shown were made from the Champlain bog, in Quebec.[1]

Mr. Doucet wished to know if the samples of Hally peat shown by Mr. Gibson had been subjected to compression.

Mr. Gibson : No, it has simply been pulped and dried by evaporation in the open air.

Peat in Prince Edward Island.

Prof. Harrington (McGill College) stated he had had some experience with peat some years ago. The best peat he had ever seen came from Prince Edward Island, where there are large deposits along the seashore from which the peat could be loaded directly into schooners. They had been told that great care must be exercised in selecting the material, and this was a very important point. Many of the peats which had passed through his hands had not been chosen with sufficient care, having run too high in ash. The suitability of peat for smelting purposes had also been spoken of, and it was sometimes alleged that iron could be made with it better than with coal. He had always understood that while free from sulphur the ash of peat was frequently high in phosphorus, which would be a serious objection to its use in smelting iron. He had no definite statistics on the point however, and it would be an interesting one to investigate. It was also to be borne in mind that if peat were made into coke a large quantity of volatile matter would be driven off, and a peat that gave say 5 per cent. of ash would yield a coke containing perhaps 15 per cent. of ash, which again showed the necessity for a careful selection of material to be treated.

Care in selection of material.

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[1] Mr. Dickson furnishes the following particulars of a comparative test of his fuel and anthracite coal made at the John Abell engine works, Toronto :

Dickson's compressed peat, weight 457½ lb ; date of test, 13th December, 1892. Temperature in boiler house, 69°, outside, 39°, of feed-water, 122°; weather dull. At 1.34 the first peat was put in with a full fire of red coal, say 6 inches deep on the grates. Steam at 85 lb. pressure, with 9 inches of water in the gauge-glass. In six minutes the steam rose to 86 lb., at which point it remained for three minutes ; it was then kept steadily at 85 lb. during the whole time of the test, the pointer only vibrating sufficiently to show the line on each side alternately. At 3.34 the steam pressure began to go down, when firing was resumed with the regular fuel. Immediately before commencing the test the boiler-tubes, ashpit and furnace were cleaned out. At the conclusion of the test the water stood at 9 inches in the glass, where it had been kept without varying during the whole of the time. Duration of test, 2 hours.

Large anthracite coal (egg), weight, 457½ lb. Date of test, 15th December, 1892. Temperature in boiler-house, 82°, outside, 31°, of feed-water, 121°; weather bright and sun shining. At 1.40 commenced firing with the test fuel with 9 inches of water in the gauge-glass. Steam at 85 lb., the fire, as nearly as could be judged, being the same as in the previous test. The steam remained steady at this pressure, with no more variation than that recorded in the other test, until 3.46½, when it began to go down, and firing with the usual fuel was resumed. At the conclusion of the test the water stood at 9 inches in the glass, being kept there steadily the whole time. As in the test with peat, the grates, boiler-tubes and ashpit had been cleaned out. The work on the engine was the same in both cases. Duration of test, 2 hours 6½ minutes.

Commenting upon these experiments, Mr. Dickson says : The test was made on a coal-burning grate, which is not quite suitable for the burning of peat, inasmuch as the surface is entirely too large. The temperature of the boiler-house when the peat was used stood at 69° above zero ; when the coal was used it stood at 82° above, making a difference in favor of coal of 13 degrees. When the peat was used the weather was dull ; when the coal was used the weather was bright and the sun was shining—a very material difference in favor of the coal, as those familiar with steam know. Notwithstanding this, 457½ lb. of compressed peat kept the steam steadily at 85 lb. for exactly two hours, while an equal weight of coal kept up the same pressure for only six and one-half minutes longer. Under similar conditions as to temperature and with a proper type of grate, peat would have done as well as the anthracite coal, if not better.

PEAT IN EUROPE TODAY.

British consular reports on uses of peat

Probably the most recent information obtainable as to the uses of peat in the various countries of continental Europe at the present time is to be found in the consular reports made to Her Majesty's Government on the subject and laid before both Houses of Parliament in March, 1893. These reports were made in pursuance of instructions given by Lord Salisbury to Her Majesty's representatives at The Hague, St. Petersburg, Stockholm, Copenhagen, Berlin and Paris to forward such information as they might be able to procure with regard to the manufacture of fuel, moss litter and other products from peat in the various countries to which they were accredited. These reports show in general that peat is still an important article of fuel in those parts of Europe where, owing to lack of coal, distance from seaports or proximity to peatbogs, it can be obtained at a less cost than coal. Other uses of peat and peat products, particularly as moss litter and in the conversion of sewage products, are also becoming more and more important, and in view of the comparative cheapness of coal in many parts of Europe it is probable that the utilization of peat will develop more rapidly there for such purposes than for that of fuel only. Moss litter is being manufactured in nearly every country in Europe. It is coming rapidly into favor as material for bedding horses, cattle, etc., one great recommendation being its capacity of absorbing moisture to many times its own weight. Considerable quantities are exported from Europe to Great Britain and also to the United States.

DENMARK.

All invented modes of treatment abandoned.

Sir H. G. Macdonell reports that all the different modes invented during the past forty years for the treatment of peat have been tried in Denmark, and have been given up as impracticable, unprofitable, or both. Expensive experiments have been carried on at Silkeborg and Moseland within recent years, but with no appreciable results. In fact peat may be said to be used merely for fuel, the people cutting sufficient for their own consumption. In some of the inland towns in close proximity to larger moors there still exists a certain demand for peat, but at seaports it seems never to have been able to compete with coal, the specific heating power being too low as compared with that of coal to enable the peat to pay expenses connected with transport to any distance. Peat for fuel is either simply cut and dried, undergoing no further treatment ('skoretorv') or it is kneaded together, and subsequently cut into regular shapes for fuel, called 'oltetorv.' In this latter shape, as in the former, it does not pay the cost of transport to any distance. To the north of the Limfjord at Lundergaard Mose, the Aalborg Mosstroelsefabrik formerly employed some fifty to seventy men in cutting peat, which was used by the railway authorities for heating their carriages. This method of heating having now given place to steam, the occupation has ceased, and a moss litter factory has taken its place.

Moss litter and

The following account is given of the way in which moss litter is used in the stables of the Copenhagen Milk Supply Company:

"Each stall is constructed with a hollow lined with cement three inches deep below the level of the floor paving. This is filled with the litter. About an inch in depth is removed daily from the surface, the fresh supply being laid at the manger end, while the supply of the day before is raked from the head to the hinder end. The litter so removed forms most excellent manure. The peat-moss litter is delivered in compressed bales of 150 lb. each, and care must be taken that it should be almost free from any moisture in order that it may be able better to absorb all moisture when in use. The company in question keep fifty horses. Though it is customary in Denmark to take but little care in grooming horses and keeping stables clean, and though there is no drain whatever in the stable in question, no trace of ammonia and hardly any unpleasant smell could be detected. The manager, Herr Busck, informed

Its commercial and sanitary values.

me that the litter for the fifty horses cost the company £100 a year, or £2 a horse per annum. The use of this article, for sanitary and economical reasons, in large towns and for cavalry barracks, cannot be overestimated, and since the same quality of peat exists in Great Britain, this industry should certainly be capable of great development."

FRANCE.

Small quantities produced,

and are confined to local consumption.

Manufactures from peat fibre.

The Marquis of Dufferin reports briefly that it appears the peat industry does not exist to any appreciable extent in the consular districts of Brest and Cherbourg ; a small quantity of peat is cut for the purposes of fuel, and in that of Marseilles turf is also used for burning in the neighborhood of Lyons, but there appears to be no appreciable commerce. In the district of Calais, again, it is reported that there is no manufacture of moss litter from peat, while the quantity cut by the peasantry has been for many years on the decrease, and in 1890 573 cubic metres only were cut at Condette and in the district of Montreuil, some 5,000 cubic metres in seventeen communes, while though there are peat bogs in the Department of the Nord, no turf was cut in 1889 or in 1890. A small quantity is also cut in the Department of the Somme As regards southwestern France, Mr. Consul Ward reports that there are peat bogs of more or less limited extent in all the Departments forming the consular district of Bordeaux from which peat is extracted for fuel, but the production is confined to local consumption. In the district of the Charente some 7,000 tons are cut annually, but the amount is far less than in former times. But the only use to which the peat is applied on the spot is for fuel. The Bordeaux Tramway Company, which tried the experiment of peat moss for litter, has now abandoned the use of it, partly because of the difficulty of disposing of the manure, and partly because the litter, which was sold to them by weight, was frequently supplied in a damp condition, which considerably reduced its utility. In Paris there are four or five firms which supply peat for fuel. There is however one important enterprise, the company known as La Beraudine, founded by M. Beraud for working his patents and manufacturing a number of articles from peat fibre, including litter, disinfecting media, blankets, carpets and rugs, mattresses, antiseptic food, preserving material, manure, etc.

In a supplementary note it is added that this Company supplies about eight different articles to the French Government, chiefly mattresses, blankets, saddle-cloths, etc., but that the number of articles manufactured from the fibre obtained by M. Beraud's process is very great, and comprises nearly all those in which felt has hitherto been used, with this important difference, that the articles are made from a woven fabric and not from a brittle material like felt.

GERMANY.

Sir E. Malet forwards a report containing much information, from which the following extracts are made :

Peat bogs worked for fuel and moss litter.

The area covered by peat bogs ('torfmoore') in Germany is very extensive, especially in the northern provinces of Prussia and the grand duchy of Oldenburg, but a small part only of this area is Government property, and no statistics of any sort are available as to the actual acreage and production. Almost all these moors are worked locally for fuel peat, and the manufacture of moss litter is also very widely spread, being carried on in East Prussia, Pomerania, Posen, Silesia, Hanover, Oldenburg, Wurtemberg, Saxony and Bavaria. The peat bogs belonging to state domains in Prussia, of which a larger number exist, are generally worked by the Government Forest Department ; many of them however are let for a term of years to private individuals, the lease being usually made out for thirty years or more, and the tenant having the right and in some cases assuming the obligation of removing all the peat during that time, thus preparing the land for agricultural development. An important moor under state management, and within a short distance of Berlin, is that of Carolinenhorst, near Stettin. It covers an area of about 2,000 acres, and is administered by the Finance Department of the Government of Stettin. Even in this case however although the peat cut for fuel is sold by the state authorities, the manufactory of moss litter is let to a private *entrepreneur.* A notable private undertaking of the kind is that of Herr Rottbarth at Gifhorn in the Province of Hanover, where both peat fuel and moss litter are produced on an extensive scale. . . . The principal products obtained from peat are:—(1) Fuel, including turf coal and turf coke. (2) Moss litter. (3) Peat dust ('torfmull') for disinfecting purposes. (4) Coarse textile fabrics, paper and various chemical products.

Peat used for fuel chiefly near the place of production.

Qualities of peat.

Employment of labor.

The use of peat as fuel is universal in the neighborhood of the moors, but is generally local. It cannot compete with coal for cheapness in any districts near the seaports or near towns which have railway communication. Peat for fuel cannot pay railway freight for more than twenty miles from the place where it is cut, and very little is ever conveyed by rail. The rate charged is about 9s. per load of 9,600 sods of peat for 10 miles. There are no available statistics either in Prussia or the other peat-producing states as to the amount consumed, but considering the wide distribution of peat bogs throughout the country it is probably very great. It is estimated, for instance, that in the grand duchy of Oldenburg alone about 150,000 tons of peat are burnt per annum, chiefly for household purposes, but also in baking ovens, brick-kilns, etc. . . . No machines are used on the Government moors in Pomerania for cutting fuel peat, but they have been employed on private moors where labor is scarce. The cost of production is not sensibly reduced by machine-cutting. The best peat for burning is generally that which lies undermost, the upper layer, to a depth of 4 ft. 6 in., being used (where it is of suitable quality) for moss litter; all beneath that depth for burning. At Carolinenhorst the peat is always dried in the open air, all other methods having proved too expensive. An attempt was made at Gifhorn to dry the peat artificially in an apparatus invented by Herr Rottbarth, but as the system was abandoned after a very short trial it appears not to have been a success. . . . The first class is the dark peat, approaching to coal, which is usually cut from the lowest stratum, and is heaviest. It shrinks most in the process of drying, a fresh sod measuring when cut 13 inches in length by 10 inches high and broad. This class of peat burns slowly, and when fifteen sods are burned in a closed stove they will leave about a large wineglass full of white ash. The second class is lighter in color and weight, and is a newer formation. The third class is the top stratum, and is of least value except in those cases where it is suitable for the manufacture of moss litter. These lower classes of peat leave more ash in burning. In some places these differences in the quality of the peat taken from the top or the bottom of the stratum do not occur, the moss being uniform throughout. The peat is sold by auction (at Carolinenhorst) and fetches as a rule: 1st class, 14s. per 'klafter' of 1,200 sods, 2nd class 10s., 3rd class 8s. The moor at Carolinenhorst employs about 500 men and women for cutting and stacking peat, chiefly for fuel. The average amount earned by a man at this work is from 4s. to 4s. 6d. per day, but they are paid according to the amount cut. The women are paid about 3½d. for every cubic metre stacked.

Best material for litter.

. . . The best material for the production of moss litter is formed by the upper strata of the 'hochmoore' (high bogs) which cover considerable areas in Hanover, Oldenburg, East and West Prussia and Pomerania. The natural vegetation of these bogs consists of moss, together with various grasses and heather (Eriphorum, Calluna vulgaris, Erica tetralix, Andromeda, Ledum, Empetrum, Vaccinium and Sphagnum cymbifolium). The decomposed remains of these plants form a dark soil overlying the yellowish-brown layers of moss peat which often attain a thickness of several yards, and in their turn overlie the older and darker peat which is used as fuel. The characteristic of the strata suitable for the production of moss litter is that in them the process of decomposition is incomplete, and that they form an extremely porous and elastic substance, which is capable of absorbing water like a sponge. In the process of drying this material contracts very little, and consequently remains soft and elastic. . .

Process of manufacturing litter.

The outlines of Hollman's system of manufacturing moss litter are briefly as follows: The moss peat is cut out of the bog in sods in precisely the same manner as fuel peat. The autumn and early winter are chosen for this work so as to allow the moss peat to freeze before drying. It is dried in stacks in the open air. At Carolinenhorst about 6½ acres, 58 inches deep, are cut each season, and yield about 3,000 tons of moss litter. The sods when dry are taken to the factory, placed in elevators and carried to a machine called the 'wolf,' which tears them into small fragments. The moss thus produced is passed over sieves to separate the peat dust ('mull') from the fibrous substance which forms the litter. It is then brought into a press which (in the case of Carolinenhorst) is 10 feet high by 2½ feet square. The pressure employed is about four horse power, and six cubic feet of the loose material are pressed into a space of two cubic feet, being then baled with six to ten laths of wood and bound round with iron wire. It is then ready for the market, and is valued at 1s. per cwt. at the railway station The moss litter factory on the Carolinenhorst moor employs fourteen to sixteen hands, of whom one-third are women, the working day being ten hours. An adult workman is paid about 2½d. per hour, a young man 2d., and a woman 1½d

Merits of the litter,

. . . It is claimed for moss litter that (1) it affords drier and healthier bedding for horses and cattle than any other material, (2) that in consequence of its great power of absorbing moisture it binds the valuable portion of the animal excrements and consequently yields the best manure, (3) that it acts as a disinfectant and improves the air of the stable, (4) that a smaller quantity of it is required than would be needed if straw were used. The published results of experiments and longer experience in the use of moss litter are not entirely consistent. In general however they are favorable, especially where horses and horned cattle are concerned; and cases of sickness conseqnent upon its use can be traced as a rule to negligence or the use of damp litter. The following is an extract of a report on the use of moss litter in the stables of the Prussian regiment of Uhlans (Lancers) No. 14, which seems entirely favorable: The regiment has used moss litter as a substitute for straw with the object of obtaining better and drier beds for the horses and reserving the fresh straw for food. This object was attained with complete success. For experimental reasons the horses were not all placed on moss litter at once. In October one-third were placed on moss litter. In November two-thirds were placed on moss litter. In December nearly all were placed on moss litter. The following advantages were observed: Dry beds and dry fresh air free from ammonia; the ceilings, walls and leather trappings remained free from moisture and mould. Moss litter absorbs eight times its own weight of urine, whereas straw absorbs only three times its own weight. The short and broken nature of the moss fibre allows of the easy removal of the wet portions. Care must be taken not to neglect to turn and shake up the litter every day and to fork it from one part of the stall to another. If these precautions are observed the animals find a dry bed, the horses remain clean and their skin in activity. If properly treated, moss litter is far more elastic than straw and affords a more comfortable bedding. The harness and saddles, as well as the boots of our soldiers are better preserved. From a veterinary point of view further advantages are observed. Catarrhs of the nose and eyes, generally the result

as shown by practical test.

of bad air in the stables, are less frequent; wounds on the legs heal quicker; inflammation of the glands very seldom occurs, and rotting of the frog is almost entirely prevented. In cases of contagious diseases moss litter is of great value and surpasses all other disinfectants.

The smaller particles which are separated from moss peat when it passes through the 'wolf' and the sieves used in the manufacture of moss litter, are collected and reduced to a powder known as 'torfmull.' This product has obtained a market for various purposes, and sells at about 1s. 3d. per cwt. It is used, according to the report, as a disinfectant, as a material for making antiseptic bandages, in absorbing the lye resulting from the treatment of molasses with strontium in sugar factories, as an admixture with salts used in powder as chemical manure, and as packing material for breakable or perishable goods.

Uses of peat in industrial enterprises.

Apart from the use of peat as fuel and in the shape of moss litter, its employment as raw material in other branches of industrial enterprise is in its infancy. Its utilization has been attempted in the following ways: A substance consisting of a mixture of peat dust, India-rubber, and sulphur has been found to be excellent material for isolating subterranean electric cables. Good porous bricks are manufactured at small expense by mixing the clay with peat dust. Pure moss-peat mull, free from admixture of grass peat or particles of sand, has been used for some time in the manufacture of gunpowder to replace charcoal. Peat fibre carefully freed from dust is beginning to be used as a material for carpets and other coarse textile fabrics The fibre is also used as raw material in some paper-mills and manufactories of celluloid. The chemical industries are likewise attempting to make use of this promising material, and gas for lighting purposes, tar, parraffin, solar oil, photogen, etc., have been manufactured from it. Matches have also been made of peat fibre instead of wood.

THE NETHERLANDS.

Curing of dredged turf.

Mr. Consul Turing of Rotterdam gives an account of the manner in which the so-called short or dredged turf is produced on the low-level moors. This is obtained by dredging with a kind of scoop, when a black and soft substance is brought forth which is spread out to a depth of five to six inches on a flooring of boards, and is then trodden down by laborers with specially adapted wooden shoes with the object of obtaining one adhesive mass. This is subsequently cut through crossways with a spade, each portion having the form of a turf, and the whole mass is then left exposed to wind and weather until the turfs have arrived at a sufficiently dry and hard state to allow of their being handled, when they are stacked in long rows to a height of 2 to 3 feet. The exposure to the sun and wind results in their drying up entirely and attaining the necessary hardness. They are then collected and stacked in large heaps with a covering of reeds, and are subsequently brought to market. This kind of turf is exclusively used for domestic purposes. Numbers of skippers with their barges proceed throughout the year to the moors in the northern provinces, where they buy the turf for subsequent retail sale in the towns and villages.

The production of peat moss has been carried on in the Netherlands for only about ten years, and in no other country has it assumed such dimensions. It is produced on the high-level moors, the upper portion of the bog or gray turf being used for the purpose.

Mixing 'fine peat with sewage for manure.

"The 'fine' litter is used for mixing with sewage, and a mixture of equal quantities produces a dry, dark, earthy substance, which can be turned over with a spade and is entirely inodorous. As a manure this product is quite as valuable as the stable moss litter; but whilst the latter in its original state is extensively used in all European countries and also in America, the mixture of 'fine' peat with sewage is but little known, although in some cities such as

Bremen, Brunswick and Oldenburg the product is largely used by the authorities. In Gothenburg, in Sweden, the 'fine' peat has been utilized for a number of years, whilst in Belgium a company has been formed for the purpose of collecting the sewage of the several towns and mixing it with moss litter and thus producing a merchantable article. Initiatory steps have been taken in Bruges and Mons, and the company will soon commence in other towns. Although the special advantages attaching to the mixture of the litter and sewage appear to be so little recognized as yet, nevertheless we think that through this industry the gray turf moors have a great future before them. In 1889 the value of one hectare (fully 2 acres) of this kind of moor was £100, whilst only ten years previously the gray turf being considered valueless, was ruthlessly cut up and thrown away, the only object being to get at the sub-strata of black turf."

Factory turf as fuel for firing brick kilns.

We now come to the subject of black turf, or as it is usually called by the trade factory turf, from its being almost exclusively used in the brick kilns along the rivers Maas, Waal, Linge, Lek and Yssel. This turf is dug up in the same manner as the gray, but care must be taken to dig only when there is no fear of frost, and also to stop digging in time to allow the turf to be quite dry before the frost sets in. The period for digging the black turf lasts therefore only from the 15th March to 15th June, whilst the gray can be worked throughout the whole year except when the soil is too hard through frost. If black turf is frozen before having dried it loses its heating power and consequently its value as a merchantable article, and then it is sold at a very low price for domestic purposes. The factory turf is conveyed in barges to the brick kilns. The importance of the trade in this article may be gathered from the fact that in the Netherlands about 280,000 tons weight are annually consumed in the manufacture of bricks, of a value of £133,000, of which £100,000 represents labor and freight. The value of one hectare good and favorably situated black peat may safely be taken at £170.

Natural turf.

Mr. Consul Robinson of Amsterdam speaks of the natural turf which has undergone no preparation save cutting from the bog and drying in the air, as having all the inconvenience and undesirability of a spongy fuel and as being unpopular as such. Hand labor is used in cutting where the bog has already been well drained. Where this is not the case cutting machines have to be used, one of the best known of which is the Victoria turf cutter manufactured by Brosowsky of Stettin, Grunhof. The natural turf is much inferior to the machine-made article, the substance of which is densified by various processes.

Pressed, washed and sifted turfs.

"The turf mass is either first disintegrated and dried in ovens and then pressed into moulds, or treated by the wet press process fresh from the peat bog (Koch and Mannhardt's system), and in this way pressed turf is obtained. Washed turf is produced by the Challeton system by passing the raw peat through rollers with knives; it is then driven by means of brushes through a fine sieve and then mixed with water, forming a pulp which is placed in casks in which the mineral and earthy parts sink to the bottom. The pulp is then dried in pans, and when sufficiently compact moulded in shapes. Sifted turf (Versmann's system) is obtained by placing the raw peat in an iron disintegrator, through which runs an axle with a serpentine knife. The finely-cut peat is squeezed out of the disintegrator through small holes, while the coarser parts pass through the bottom opening of the disintegrators. The expression 'machine-made turf' includes all those descriptions of turf in manufacturing which the fibre of the peat is cut by machinery and remixed in such a manner as to form as far as possible a homogeneous product, even where turf presses for condensing the same are not used. It may be assumed that nine cubic metres of fresh peat will produce six cubic metres of wet machine made turf, that is seven (?) cubic metres of dry machine-made turf weighing 200 kilog. The specific gravity of air-dried, hand-cut turf is on an average .2, that of the air-dried machine-made turf .6 to 1.3, according to the quality of the raw material. Air-dried machine-made turf contains up to 30 per cent. of water, and as this must be evaporated during combustion there is a considerable loss of heating power. In order to lessen this, drying ovens of various construction have been tried. Turf is also converted into charcoal in the same manner as wood, both in heaps and specially constructed ovens. Turf charcoal is nearly equal to wood charcoal in heating effect, but is not so useful as the latter, as on account of its porous nature and proportionately large residuum of ash the fire is less intense. . .

Turf charcoal.

"The secret of the success and of the profitable working of the moors and bogs in Holland, and of the generally flourishing condition of her turf industry lies nearly altogether in cheap means of transit. All the principal turf-producing centres are intersected by canals capable of being navigated by the large turf-carrying lighters, from 80 to 200 tons dead weight capacity, and as the bog is opened out for turf-cutting the canals are simultaneously pushed forward, so that the expense of transit at the place of production is reduced to a minimum. As regards the home consumption of turf, it is also so regulated as to do away with every manipulation of the article which can possibly be avoided. . . The expense of carriage to the port of shipment, even under the above favorable circumstances is 25 to 50 per cent. on the cost of production, and it is very clear that the article is one which cannot possibly bear any extra expense of manipulation or transport. The climate of this country, though more humid than that of most parts of the continent of Europe, is still sufficiently dry, especially in the early part of the year when lengthened periods of dry easterly winds prevail, to encourage the production of turf, while the consumption as a household fuel prevails so very generally over the whole of Holland that in spite of the competition of coal and coke it continues to hold its own in this respect. Besides this household consumption, the brick-making industry is the chief consumer of turf, which is transported by lighters direct from the bogs to the brick-making establishments, situated in great numbers along the principal rivers of Holland, where brick clay of an excellent quality is found. The consumption for this purpose is a very large one, the turf forming a clean, practical and economical fuel for brick-burners, whose ovens are specially arranged for its use."

Profitableness of production depends on cheap means of transit.

RUSSIA.

According to Mr. Consul Michell at St. Petersburg, peat fit for fuel is found in Russia in forty-five of its provinces on an area which it is calculated extends over 100,000 square versts (67,000 square miles), and is capable of yielding 875 milliards of poods (14 milliards of tons). No exact information as to the quantity of peat cut in Russia is in existence. It can only generally be said that it is found in the provinces of Moscow, Vladimir, Nijni-Novgorod, Orel, Kharkoff, Kieff, Esthonia and St. Petersburg, where it is prepared as fuel for manufactories, sugar works and other industrial establishments, as also for locomotives. Among the peat bogs which belong to the crown those lying in the provinces of St Petersburg, Moscow, Orel, Riazan, Vladimir, Tamboff and along the Kursk-Kieff line have been surveyed. The result of the survey proves that the peat bogs of the crown in the above localities contain no less than 100 millions of cubic feet of peat of excellent quality. Some of these peat bogs are leased under the crown by private individuals, notably in the district of Pokrovsk, of the province of Vladimir, the lessees of which are Savva, Morozoff & Co, owners of the extensive Nikolsky cotton manufactory. Peat bogs belonging to private individuals are worked near the station of Orekkhova of the Nijni-Novgorod railway and in the neighborhood of Moscow, viz, at Krilobsky, nine miles west of that city; at the village of Nikolsky, along the high road leading to

Extensive areas of peat in Russia.

St Petersburgh; near Gorenky station, on the Vladimir road, where it is worked for the Reutovsky cotton mill of the Morozoffs; near the station of Libertsi of the Riazan railway, in several parts of the provinces of Orel, and in the neighborhood of St. Petersburg.

Manufacture of compressed peat.

The peat used in Russia appears to be for the most part of the ordinary hand-cut, air-dried variety, but an account is given of establishments at Perst and at New Woidoma in which machinery of German manufacture is employed for the production of peat in a compressed form. These appear to be in successful and profitable operation, and it is stated that the working expenses of the establishment at Perst were almost completely covered in the first year.

SWEDEN AND NORWAY.

Production and uses of moss litter.

Manufactories for the preparation of moss litter have been established in various parts of Sweden and Norway, and the value of peat mould (torfmull) as an antiseptic and for covering fæcal matter, which in Swedish towns is carted away solid, is being largely recognized. Mattresses and other articles of bedding are also manufactured from the peat fibre, as well as loose inside soles for boots and shoes. For surgical purposes and compresses the moss is chemically prepared with disinfectants.

Mr. Consul Duff of Gothenburg states that in his district peat is not yet used for industrial purposes on any extensive scale; some glass-works however having large tracts of peat in their immediate neighborhood have found it to their advantage to work the peat, and usually employ machinery of German construction for raising and shaping the material into a form of less bulk. Mixed with small coal it makes an excellent fuel. Also some iron-works use peat, but not largely; it is of course unmixed, and only used for certain purposes owing to its purity.

Mr. Duff also gives the following particulars respecting the manufacture and export of moss litter within his district:

Raising,

"By means of sharp spades the peat is cut into lumps about the size of a large brick, which are spread on the peat bog to dry. After some time these are gathered into small piles and placed so as to admit the access of the wind to take away all moisture.

housing.

"When the process of drying, which takes from a few months to a year, is completed the peat is collected and conveyed on portable rails to the barn, or placed in large stacks or piles to protect it as far as possible from rain.

manufacturing and

"The peat is now ready for the machinery, which in most cases is worked by steam. The lumps or bricks are brought in contact with a rotating wheel fitted with sharp steel pegs and are instantly torn to pieces, whereupon it is carried by an elevator to a large revolving screen where the separation of the two qualities of moss litter, namely, 'torfmull' and 'torfstro' takes place; the former being a soft substance similar to cigarette tobacco is used for closets, and the latter which is of the consistency of oakum is mostly used in stables and cowhouses.

baling the litter.

"Powerful presses compress the litter into bales, which are held together by means of wire and wooden ribs. The size of the bale is 100 x 75 x 50 centimetres, and the weight about 100 to 120 kilog. The price is 20s. per ton free on board at Gothenburg.

Export trade.

"Although there are numerous enquiries for Swedish moss litter, particularly from Great Britain, still the export is very insignificant, owing principally to the high freights and the difficulty in reducing the weight of the litter.

"The average weight of the Swedish litter is 15 to 20 kilog. per hectolitre, whereas that of the Dutch litter, which in every respect is far superior to the Swedish, and of which a considerable import to Sweden takes place, is only 10 kilog. per hectolitre."

The following information on the present position of peat products in Sweden is given by Herr Th. Palmberg of Stockholm, his letter being dated August, 1892:

Great area of peat bogs in Sweden.

A growing industry.

"The peat bogs of Sweden cover an immense surface, amounting to many millions of acres, nor are they confined to any one part of the kingdom, though the largest of them are either in the extreme northern provinces or in the provinces of Dalecarlia, Vermland, Smaland, Halland and North Scania. In Upper Noorland and in Lapland there are peat bogs hundreds of square miles in size, and consisting of turf of excellent quality; in other provinces the bogs have turf of different qualities, and occasionally different qualities of turf are met with in one and the same bog. The depth of the turf varies from 3 to 37 feet, and even more. It is an old custom in the southern provinces to burn turf as fuel in private dwellings; especially is this the case in provinces along the coast where there is no wood to spare for burning. To a certain moderate extent bogs were also formerly used for raising crops. But for the last thirty or forty years increasing attention has been paid to the profits attainable from Sweden's plentiful supply of peat bogs, both as regards their cultivation and as regards the fuel to be obtained from them for use in dwellings and in manufactories. During the last ten years increasing interest has also been evinced in the supply of peat litter.

"To show the possibilities of their cultivation it may be mentioned that over 600,000 acres of bog have been brought into cultivation in the southern and central provinces during recent years. In these same provinces turf for burning is now cut out in enormous quantities every year by most of the iron-works and other industrial establishments situated inland and possessing bogs of their own.

Processes of the manufacture of peat.

Curing with surplus heat of iron furnaces.

"There are numerous ways of treating the turf (when cut) by machinery. There are different machines for disintegrating, rolling and pressing it, and making it hard after drying. The actual drying generally takes place on a flattened out piece of bog itself, either by spreading it out or putting it up on frames. Besides the above air-drying of the turf, several iron-works have of late years established ovens of various sorts for the further dessication of the turf. These ovens have in general given very good results. They are heated by the surplus heat of the furnaces, which thus costs nothing, and yet the turf gains from 25 to 30 per cent. in value from the process.

Peat fuel for dwelling houses and for industrial purposes.

"The ordinary turf for burning in dwelling houses in the southern provinces where wood is scarce is chiefly cut brick-shape by spades made for the purpose and then dried at the place where it is cut by simply spreading it out in small heaps. It costs very little to cut, but is rather loose owing to its being treated in so primitive a fashion. Such turf as is intended for industrial purposes is always worked up or disintegrated in one way or another, so as to be hard and solid when dried and thus give more heat when burnt. At iron-works turf is used in the furnaces either by itself or else mixed with coal and fir cones. At wood-pulp factories it is used for drying the pulp. Turf is also burnt in glass-works, brick-works, as fuel for steam engines, etc. It is only in the south of Sweden, and even there in but few cases, that there are factories for the preparation of turf for sale as fuel.

Increasing use of the fuel.

"It is impossible to give any exact figures as to the amount of prepared turf yearly produced in Sweden for burning, as no figures are recorded. Its use is increasing year by year owing to its being a cheaper fuel than coal. About 25,000 to 30,000 tons a year may be said to be employed in metallurgical works of different kinds.

Cost of production.

"The cost of producing well made turf for fuel may be given as from 4s. 4d. to 5s. 5d. per ton, according to the price of labor in different places. Good turf for fuel is expected to contain from 30 to 40 per cent. of heating material, and not above 7 to 10 per cent. of ash, and there is an enormous quantity of such turf in Sweden.

Peat litter factories.

"Of late years quite large quantities of peat litter has been prepared in southern and central Sweden, partly by twenty large peat-litter factories which produce it for sale, and partly by private owners of peat bogs who take it for their own use. It is of the very best quality, far excelling that produced in other countries. This peat litter is made from pure sphagnum, or immature moss unmixed with other sorts of moss. Each peat-litter factory makes about 15,000 to 30,000 bales (200 lb. each), and it is sold here in Sweden for about 1s. 8d. per bale. A much finer quality (called torfmull) sells for from 1s. 11d. to 2s. 2d. per bale."

XVI.

THE MINING LAWS OF ONTARIO.[1]

Ontario.

The first Mining Act.

Early control exercised by Orders in Council and reservations in the patent.

For three-quarters of a century Ontario was known as Upper Canada. For two thirds of that period it had a Legislature and Executive of its own, and for the rest of the time it was united with Lower Canada, now Quebec. The union of the two Provinces ended with June, 1867, and on the first day of July Upper Canada became a member of the new Confederation with the name which it now bears. Three years before this date the first statute regarding Mines and Mining was enacted by the Legislature of the United Provinces, having for its title "The Gold Mining Act." This and the Amendment Act of 1865 were the only statutes which dealt with Mines and Mining down to the date of Confederation; all other control was exercised under the authority of Orders in Council and by reservations in the patent from the Crown. Under the latter provision gold, silver, copper, tin, lead, iron and coal were so reserved down to the end of 1823, and gold and silver until the 13th of July, 1866, when a regulation was approved by the Governor General in Council directing that in all letters patent for lands the clause reserving mines of gold and silver be omitted.

EVOLUTION OF THE LAW.

From particulars to general principles.

Successive Regulations, 1845-53

Priority of claims.

Area and price of mining locations.

The necessity for exercise of Government control over mineral lands and mines arose in 1845, the first year of exploration and discovery on the north shore of lake Superior. At first each case requiring executive action was dealt with by Order in Council as it came up, but in the course of time certain principles were evolved to which general application was given under the form of regulations. These however were changed six successive times within the space of one year and after a seventh modification in January of 1847 they stood unaltered for nearly seven years. For license to occupy a location and open mines thereon priority of discovery by exploration was a first requirement; but no license could issue until the explorer reported the result of his discoveries to the Government. It was also necessary that a scientific agent of the Government should have an opportunity to mark the boundaries of limits, determine the direction of boundary lines in the case of different courses of veins on adjoining locations, and examine the statements of exploration furnished by an applicant. Reports pointing out and selecting a location were classed according to receipt and held to be the best evidence of discovery; possession by the building and occupying of a hut was proof of the next value; while priority by application was assigned a third rank of value. The extent of a mining tract was first fixed at one mile in front by five miles in depth; but afterwards in response to the petitions of explorers the limit was extended to two miles in front by five in depth, the length to be with the course of the mineral vein. The land was sold in fee simple at eighty cents (4s) per acre, $600 payable at the time of purchase or when the certificate of location was issued, to cover the cost of surveying and other contingent expenses, and the balance in five yearly payments with interest. Upon these terms the lands on lakes Huron and Superior were declared open for sale at the minimum price of four shillings per acre in blocks of ten square miles; and although it was provided that all grants should be subject to such regulations to ensure the working of the mines as Parliament might thereafter enact, it does not appear that any conditions were required or imposed by that body.[2]

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[1] A paper read at the meeting of the International Mining Convention at Montreal, February 24, 1893. A. B.

Regulations of 1853.

After a trial of seven years the Government became convinced that these regulations were too burdensome upon the miners. The system of allotting mining tracts had not realized the anticipations formed of it; neither had it enabled individuals desirous of engaging in mining pursuits to effect their objects without compelling them to purchase locations of so extensive an area as to call for a needlessly large outlay on acquiring a right to explore and mine where the signs were favorable. Accordingly in September, 1853, a new set of regulations was introduced by Order in Council, applicable to Upper Canada only, under which the Commissioner of Crown Lands was empowered to issue to any person upon payment of $100 (£25) a license to explore unceded lands in any county or section of the Province (named or described in the license) for copper, lead, iron, tin, marble, gypsum, earths or minerals. The license was to remain in force for two years and the holder of it might take possession of a tract not exceeding 400 acres of unoccupied land, 40 chains front by 100 in depth, and "report his discovery and selection accurately by letter and map within six months from the issue of the license, accompanied by an affidavit made by himself and some other credible person proving that no counter occupation or workings exist." At the expiration of the term of two years the license holder was required to complete a purchase of the tract selected by him at the rate of $1.50 (7s. 6d.) per acre in one sum or forfeit his right. It will be observed that these regulations did not apply to gold and silver unless they could be included under the general designation of minerals.

Regulations of 1861.

In the next regulations adopted by Order in Council in March, 1861, gold and silver were specifically excluded, as doubtless it had been intended all along that they should come under the regulations of 1845-7. The new regulations also abolished the fee of $100 for permission to explore, and provided that locations be sold to the first applicant agreeing to the following conditions, viz: "That for mining purposes tracts comprising not more than 400 acres each be granted to parties applying for the same at the rate of $1 per acre to be paid in full on the sale," the applicant furnishing a plan and description of the locality to the Department of Crown Lands, "and on condition that such mineral location be worked within one year from the date of the said grant." It was further provided that a patent should not issue until two years from the date of the purchase, and then only upon proof that the purchaser or his assignee had continued to work the location *bona fide* for at least one year previously.

Regulations of 1862.

Royalty.

In April of the following year working conditions were abandoned as to future sales, and it was agreed that patents should issue on the payment of the purchase money, but subject to a royalty of 2½ per cent. on ores raised or mined, payable on their value as prepared for market at the mine.

changed to a specific tax on all ores except gold and silver in 1864;

In March of 1864 the royalty of 2½ per cent. was changed to a tax or duty of $1 per ton on all ores except gold and silver, payable on removal from the mine, and this condition was made to apply to all mining lands sold under the regulations of 1862. It was also provided by the amended regulations of 1864 that not more than one tract of 400 acres should be sold to one person.

but royalty and reservation practically abandoned in 1865.

The new tax or duty remained in force only one year, a regulation of April, 1865, directing that the clause requiring such payment should no longer be inserted in the grant or patent. The same regulation also authorized the Commissioner of Crown Lands at his discretion to omit the clause reserving mines of gold and silver in patents for lands on the shores of lake Huron and lake Superior.

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[2] The Mining Location ticket issued under the Rules and Regulations of the Orders in Council of 7th October and 2nd November, 1846, contained the condition that if the locatee should neglect to commence and *bona fide* carry on mining operations upon his location within the period of eighteen months from the date thereof he should be held to have forfeited the location and license.

Regulations of 1866.

The last of the regulations for the sale of mineral lands by Order in Council were brought into operation in July, 1866, and dealt chiefly with ores of the base metals. They provided for the sale of mining tracts in unsurveyed territory in blocks of 200 or 400 acres; the survey of tracts at the cost of the applicant by a Provincial Land Surveyor; the furnishing of plans, field notes and descriptions showing the connection of a tract with some known point in previous surveys, so that it might be laid down in the office maps of the territory; and payment at the price of $1 per acre at the time of making application. These regulations also provided that lands in unsurveyed territory should be sold by the Department and in surveyed townships by the local agents, and that in all letters patent for lands the clause reserving gold and silver should be omitted.

The Gold Mining Act of 1864.

In 1864 there was a rush of miners and prospectors to regions of Lower Canada in which alluvial gold had been discovered, chiefly on the St. Francis and Chaudiere rivers and their head waters; and in that year, as already mentioned, the Legislature passed the first Act on the subject of Mines and Mining known as "The Gold Mining Act." It was a statute of 40 sections, drawn up with much nicety and particularity for the mining of alluvial and quartz gold and the protection of miners' rights, for appointment of inspectors of divisions with large powers, for staking out claims of small areas, for licenses to mine, for licenses to mill, for sworn returns of gold taken out, for preservation of the peace, and in short all the trappings which the wit of legislators might devise for conserving the interests of the Crown and protecting the rights and fixing the obligations of miners in a placer diggings gold land.

Exclusive powers to make laws for management and sale of public land assigned to the Provinces by the B. N. A. Act.

Gold mining in Hastings.

The rush of miners and prospectors to the Chaudiere valley was of short duration. Yet the Act of 1864 not only remained with trifling amendments the law of the country down to the end of the union of Upper and Lower Canada; it continued to be the law after Confederation, when the exclusive powers to make laws for management and sale of public land belonging to each Province was assigned to the Provincial Legislatures by the new constitution, the British North America Act. A good reason for its continuance in Ontario was found in the discovery and working of veins of gold quartz in the county of Hastings, which had been set apart as a mining division under the Gold Mining Act on the 17th of November, 1866, ten days after the Commissioner of Crown Lands had received information of the discovery of gold in Madoc.[3]

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[3] Under date of November 6th, 1866, Hon. Billa Flint of Belleville wrote the following letter to the Commissioner:

MY DEAR SIR,—There is a great stir here at present about Gold in Madoc.

Already one lot has been sold to Americans for about $30,000, and the gold is very rich; it also begins to be developed in other places in Madoc than on lot 18, 5 con.

My object in writing is to say to you that I believe it exists in Elzevir, Hungerford and other townships both east and west of Madoc, and my desire is to put you on your guard as to sales of land, as the people are going mad about lands for mining purposes.

I have for years been satisfied that there was a vein of gold running somewhere about east and west across the Back Country, and have had several specimens from Quartz Rock for the past five years.

I know Geologists will not admit that we have mineral wealth, but I do know that they cannot tell where mineral is until we find it for them; and I have no faith in their statements, for when I have given Sir Wm. Logan specimens he won't return them, nor tell me what they are.

The present excitement if kept up for a short time will bring our rocky land to high figures. Lands near this Gold discovery that could have been got for 4$ an acre 10$ is refused for them now; this shows the sanguine feeling of both holders and purchasers.

So if there is any good chance, of which I have no doubt, let the Government enjoy for the good of the whole country the benefit by sale or leases. Yours, etc., etc., BILLA FLINT.

HON. A. CAMPBELL, Commissioner of Crown Lands, Ottawa.

On this letter the Commissioner made a memorandum as follows:

I have no faith in the gold being found in paying quantities; the Chaudiere country promised much greater riches, but the only persons who have made any money there have been speculators on the delusion of others in the price of lands, and the few who have found gold in alluvial deposit. If there be any Gold in the Townships named by Mr. Flint it is in situ and the expense of working it will be found to reduce the affair to the laws of ordinary industrial pursuits. The lands however in the Townships named should be treated as Gold lands are in Chaudiere- sold at a price of $2 per acre cash, subject to Gold Mining Act.—A.C.

Gold and Silver Mining Act of 1868.

Miner's license.

In the first session of the Legislature of Ontario after Confederation the Act of 1864 was repealed, and one known as "The Gold and Silver Mining Act of 1868" was enacted in its stead—provision for silver mining having been deemed necessary as a result of discoveries on the north shore of lake Superior in the previous year. The new features of this Act related chiefly to the granting of licenses to explore and mine for gold and silver within the limits of a mining division, and to the levying of royalties. Under the former Act a miner's license was of two kinds, viz., (1) a Crown Lands license, which upon payment of a fee of $2 per month authorized the holder to mine on any unsold public lands, and (2) a Private Lands license, which upon payment of a fee of $1 per month and after agreement with the proprietor authorized the holder to mine on any private lands within the limits of the division. Under the latter Act the fee for a license was reduced to $5 per year, and it authorized the holder to explore and mine for gold and silver upon any public lands in a division, but subject to the levy of a royalty of not less than two nor more than ten per cent. on the gross amount of gold or silver mined—the rate to be fixed by the Lieutenant-Governor in Council and variable for different mining divisions and different mines according to the yield. Proprietors of private lands were accorded the right to mine for gold and silver upon their own lands, subject to the royalty, and private licenses were abolished.

THE GENERAL MINING ACT OF 1869.

The first Act to deal with all ores and minerals by legislation.

The old regulations crystallised into statutory law.

Royalties abandoned and reservations made void.

In the following year this Act was repealed, and there was passed in place of it "The General Mining Act of 1869," a measure which for the first time dealt by legislation with ores and minerals of all classes. It however retained most of the provisions of the former Act, applying them to the occupying and working of "mining claims" under miners' licenses when situate within any mining division, but abolishing the provisions relating to alluvial mines. Larger areas were designated as "mining locations," consisting of 80, 160, or 320 acres, the price was fixed at $1 per acre, and if the locations were in unsurveyed territory it was necessary to make a survey and file plans and descriptions as required by the regulations of 1866. To a large extent indeed the old regulations became in this measure crystallized into statutory law. By this Act also all royalties, taxes and duties reserved by any patent theretofore issued in respect of any ores or minerals were declared to be repealed and abandoned; all reservations of gold and silver mines contained in any previously issued patent were rescinded and made void;[4] and it was provided that no reservation or exception of mines or minerals should thereafter be inserted in any patent from the Crown granting any lands sold as mining lands.

These general references to the Act of 1869 will suffice to exhibit the course of the development of mining legislation in our Province; but I pass by the details and take up the law now in operation.

THE MINES ACT 1892.

Divisions of the Act.

In "The Mines Act, 1892," the Act of 1869 and all subsequent Acts dealing with mining lands, mines and mining have been consolidated and amended. It consists of four parts, viz.: General Provisions, Mining Locations, Mining Claims and Mining Regulations, and for convenience it may best be considered under these several heads.

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[4] It has been stated that most of the patents issued down to the end of 1823 reserved for the Crown mines of copper, tin, lead, iron and coal, as well as of gold and silver; but inasmuch as only the two last named were by the Act of 1869 deemed to have passed with the lands to the owners in fee simple, it may be assumed that the right to the others in all cases where the reservation was made in the patent is still in the Crown.

Bureau of Mines.

The administration of the mineral lands is presided over by the Commissioner of Crown Lands, and connected with his Department is a Bureau of Mines, established to aid in promoting the mining interests of the Province. The Director of this Bureau acts under the instruction of the Commissioner, and is clothed with all the powers, rights and authority which an inspector or local agent may exercise in a mining division or locality, and such other powers as may be assigned to him by regulation for carrying out the provisions of the Act. In practice the Bureau has charge of the mineral lands in surveyed territory (unsurveyed territory is in charge of the Department), and through it all correspondence and business relating to the selling, leasing and working of such lands is carried on. It also publishes an annual report to furnish information on the mineral resources of the Province, the progress of mining and metallurgical operations, the conditions of mines as regards the health and safety of miners, and the observance of regulations for the employment of labor.

Royalties on ores and minerals.

As in the original Act, any person may explore for mines or minerals on any unoccupied Crown lands, and such lands if supposed to contain ores or minerals may be taken as mining locations, or if in a mining division as mining claims. But lands so taken do not now carry the ores or minerals absolutely with the fee simple, as any acquired subsequently to the 4th day day of May, 1891, are subject to a royalty for the use of the Province. It is an interest which the Crown reserves in mineral lands, and may be regarded as part of the price put upon them by the Act at the time of sale or lease. Accordingly no higher rate of royalty may be levied than is provided by the statute in force when the lands are granted. The royalties are in no case to be imposed or collected until after seven years from the date of the patent or lease (but extended in the case of original discovery to fifteen years), and then they are to be calculated upon the value of the ores or minerals at the pit's mouth less the actual cost of labor and explosives employed in raising them to the surface. In this way and under these conditions silver, nickel, and nickel and copper ores are subject to a royalty of three per cent., iron ore to two per cent., and all other ores to such royalty as may be imposed by Order in Council not exceeding three per cent.[5]

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[5] The question of royalties upon minerals has been warmly debated in Ontario during the past two years, and the Legislature has been charged with adopting in this matter a repressive and reactionary policy towards the mining industry. Yet it has never been shown how royalties paid to the State differ from those paid to a private owner ; and throughout Europe and America the private owner of mineral land is often found leasing his property to a miner or company of miners, and levying rents and royalties like any lord paramount of a kingdom. In some countries this is the prevailing practice ; but occasionally the charges are found to be so heavy and the conditions so exacting that the miners prefer to buy the property outright at any price that can be agreed upon. Thus a few years ago the Reading Railway Company paid $50,000,000 for 100,000 acres of coal lands in Pennsylvania, which has proved to be a ruinous bargain ; and doubtless the lessees of Dolcoath mine in Cornwall would also have preferred, if they might, to pay an enormous sum for the fee rather than submit to the owner's fine of £25,000 at the last renewal, although he had up to that time been paid £260,000 in royalties and had not contributed a dollar to the development of the property.

In the case of the private owner there is no uniformity in the rate of royalty, which depends in part on the known or supposed value of each separate location, and in part upon the success of the owner in making a good bargain, the aim always being to get the highest rate and best terms possible. Furthermore, in addition to royalty a fixed rental is sometimes provided for, with a premium or fine at the time of renewal. In the case of an iron ore property in Scotland some years ago the fixed rent was £12,000 a year, and 7s. 6d. per ton royalty. In Michigan, Wisconsin, Minnesota, New York, New Jersey and Pennsylvania, owners of mineral lands are paid large sums every year as royalties, although often their only investment has been the payment of the original purchase price to the State.

On the Mesabi iron range in Minnesota twelve mining locations were leased last year at royalties ranging from 30 to 65 cents per ton, the average being 53 cents. Under the terms of the contracts the lessees are bound to pay royalties on a minimum output of 1,550,000 tons each year, the aggregate of which will be $820,000. Eleven of those properties were purchased from the United States Government at $1.25 per acre, and the owners will derive from them a yearly income of at least $560,000 in royalties. One property of 160 acres is land leased from the State under a royalty of 25 cents per ton, and it is sub-let subject to a minimum yearly output of 400,000 tons and a royalty of 65 cents per ton On this output therefore the State will receive $100,000 a year, while the private lessee will receive $160,000.

Mining locations, their area and price.

Mining locations are required to be of definite form and size, whether they are situated in unsurveyed territory or in townships surveyed into sections or lots. In the territory beyond lakes Superior, Huron and Nipissing and the French and Mattawa rivers, wherein for the most part the great mineral-bearing formations of the Province lie, each location in a surveyed township must consist of a half, a quarter, an eighth or a sixteenth of a section; and if in unsurveyed territory it must be of rectangular shape with outlines of astronomical bearings, containing 320, 160, 80 or 40 acres, surveyed at the cost of the applicants and connected with some known point in previous surveys or with some other known point or boundary. The price of such locations ranges from $2 50 to $3 50 per acre, dependent on its distance from a railway and whether it is in surveyed or unsurveyed territory. For locations south of lake Nipissing the price ranges from $2 to $2.50 per acre. Any greater sum however may be charged where a district or locality rich in mines or minerals has been set apart by regulation under Order in Council, or the land in such a locality may be temporarily withdrawn from sale.

Tenure of locations by grant in fee simple, or by leasehold for a term of years.

The applicant for locations has the choice of obtaining a grant in fee simple at the prices named above, or he may obtain a lease at $1 per acre for the first year and 25 cents per acre for each subsequent year if the lands are in the territory north of the lakes; if south of the lakes the first year's rental

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Discoveries of ore on lands owned and leased by the State promise already an annual income of a quarter of a million, to be paid directly into the State Treasury in the shape of royalties, and according to H. V. Winchell of the State Geological Survey the revenue of the State from this source will within three years reach a million dollars. Upon the twelve sub-leases of locations on the Mesabi range already made the holders from the State and Federal Governments have been paid $270,000 of royalties in advance of any working, and nearly all the iron mines in this State are paying royalties to the private owners. By the Act of 1889 the State leases its iron bearing lands under a fifty years contract at a royalty of 25 cents per ton (the minimum being fixed at $1,250 a year whether ore is raised and removed or not), but its provisions do not of course apply to lands purchased from the Federal Government.

In Pennsylvania the ores and minerals in public lands have gone to the purchaser of the surface rights, including extensive land areas of hard and soft coals. Mining companies have purchased blocks of these lands from the private owners at prices ranging from $200 to $500 per acre, but usually the lands have been let by the holders to miners at royalties ranging from 25 to 50 cents per ton. How such parties have benefited by the bounty of nature is well illustrated by the case of the Girard Estate lands in Schuylkill county. When hard coal was first discovered in this county about a hundred years ago the land was quickly taken up at the low price at which public lands in the State were then held, but for more than thirty years no mining operations were undertaken upon it. About 1828 a block consisting of 18,233 acres was bought by Stephen Girard under foreclosure sale by the State "at practically nominal prices." The management of this land passed into the hands of the Philadelphia Board of Directors of City Trusts in 1832, as provided by Mr. Girard's will, but no coal was raised upon it until 1863, when lots began to be leased to mining companies at a specified royalty, increasing one cent per ton a year for fifteen years—the term of the lease. In the first year the revenue from the mining lots was $4,246. In the last year, 1892, it was $623,699, whereof $618,096 was from royalties (nearly 42 cents per ton), and the balance from rents—"a sum," the directors say in their report, "which will be largely increased for many years, and from which there will be no material decrease for twenty-five years at least." Three-fourths of the net receipts from royalties is credited to capital account and permanently invested, but "these receipts increase so rapidly that it is difficult to find legal investments for them." The sum now invested by the board, a portion of which however has come from other sources of the estate, is $3,378,925, and last year it yielded an income of $139,839. Had the State reserved the minerals the revenue on the quantity of hard coal sent to market last year, calculated on the royalty paid upon coal taken from the Girard Estate land, would have been $17,385,000; and had half the rate been paid upon soft coal in addition, the aggregate for royalties paid in the year would have been $25,000,000. In so far as the price of coal is affected, it could make no difference whether this money was paid to private individuals or the State Treasury; but as a matter of public interest the difference is obvious. The advocates of private ownership will say, as some of them have said, that reservation of minerals by the State hinders development, and that private ownership tends to promote it. This has not been the case in Pennsylvania, where most of the best coal lands were held in idleness by the private owners for more than a generation.

"Minerals in the United Kingdom," the Final Report of the Royal Commission on Mining Royalties says, "are usually worked by lessees and not by the proprietors." This Commission was appointed in August, 1889, the evidence and information which it collected, including the final report, has been published in five volumes or blue books, and its work was not concluded until March 24th, 1893. These two paragraphs, in which the leading conclusions and recommendations are summarized, are all that need be quoted here: "1. We estimate that the amount paid as royalties on coal, iron-stone, iron ore and other metals worked in the United Kingdom in the year 1889 was £4,665,043: and that the charge for is 60 cents. per acre and 15 cents thereafter. Leases are issued for a term of ten years with a right of renewal for a further like term at the same rental if the conditions have been observed, and thereafter they may be renewed from time to time every twenty years at such rent as the regulations provide. But the lessee may at any time become the purchaser of the lands held by him, in which case the sum paid for the first year's rental is treated as part of the purchase money. This leasing system appears to be growing steadily in favor with mining men, and a large proportion of the lands now granted for mining purposes are granted under its provisions.

Locations granted subject to working conditions.

Whether a location is held in fee simple or by lease it is subject to certain working conditions, being an expenditure during the first seven years after the issue of the patent or lease in actual mining operations of $4 per acre where the area of the location exceeds $160 acres and of $5 per acre where it if of less area ; and such expenditure may consist of labor performed by grown men at the rate of $2.50 per day, or for explosives or other material for mining used on the location. In default of so much work by a *leaseholder* the lease becomes void and the location reverts to the Crown ; in a case of default by an *owner* all mines, minerals and mining rights so revert, but the owner retains all interests in the location as agricultural land.

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wayleaves for the same year was about £216,000. II. We are of opinion that the system of royalties has not interfered with the general development of the mineral resources of the United Kingdom, or with the export trade in coal with foreign countries."

Coming back now to Ontario, one or two instances of the working of private royalties may be cited. The lands of the Canada Company are either leased for a term of seven years or sold in fee simple. In the former case the lessee covenants not without leave in writing to open any mine, or dig or bore for oil or natural gas, or allow any work connected therewith to be carried on upon the premises. In the latter case the land is conveyed subject "to the reservation of all or any of the mines, minerals, mineral oils and natural gas on, in, or under the said lands," and to such powers, privileges and covenants to the company for searching for, working, getting and disposing of the same as the company may deem proper. In one case reported last year this company let a phosphate location in the county of Frontenac at a royalty of $2 per ton. The other instance is drawn from the discussion which took place at the meeting of the International Mining Convention upon the reading of this paper. Mr. Ian Cameron, manager of the Dominion Mineral Company's work at Sudbury (who expressed a decided opinion favorable to the Ontario mining law), said he had been in charge of the company's business only a few weeks when numerous offers were made to him of unimproved lands held by private owners in small lots at prices ranging from $40,000 to $100,000 and royalties in addition ranging from 25 to 50 cents per ton upon nickel ores. And the parties from whom those offers came, Mr. Cameron said, were the ones who made the strongest objections to The Mines Act. In the sale or other disposal of mining lands the interests of the country ought to have the chief consideration, and in his opinion these had been conserved by the Act, while at the same time the miners were treated with fairness and liberality.

Now as to the conclusion of the matter. In almost every country, but especially in Great Britain and the United States, the practice largely prevails amongst owners of mining lands to levy royalties on the minerals raised from them. There is no uniformity in the rate of the royalties, or of the rent charges for occupying the lands, or of the time for which the lease is to run. Everything depends on the opportunities for driving a good bargain ; and almost invariably every ton of ore mined must pay royalty to the owner of the land whether there is profit in it for the miner or not, and a certain amount of royalty must be paid every year whether the ore is mined or not. Under the Ontario Act, if the land is sold in fee simple it is the owner's, to make the best use he can of it, but subject to the royalty provided by the Act at the time of sale ; if it is leased, the lease is for a fixed term and renewable. The royalty is fixed also and cannot be increased, although it may be reduced ; and if the miner does not make any profit on the ore he wins—if its value at the pit's mouth is no more than the cost of labor and explosives in raising it—the Government can exact no royalty from it. If then the system of private royalties is free from objection, if as in Great Britain a tribute of $23,000,000 a year may be imposed on the industry by the private owners of mineral lands and not interfere with the general development of the mineral resources of the country, how can it be affirmed that a very much lower and fairer rate of royalty can repress or interfere with it in Ontario where, when royalties begin to be levied at all, they will be paid into the Treasury of the Province instead of to the private owners of lands that once were the lands of the whole people ? Or is a State the only landowner which cannot take the measures commonly adopted by individuals and companies to derive a revenue from royalties without being accused of adopting a repressive and reactionary policy by the parties who themselves are seeking to make incomes and fortunes out of royalties? If a share in the bounty of nature, such as unquestionably ores and minerals are, may justly be reserved to the people, the time to provide for it is while the lands are part of the public domain, not after they have been sold or otherwise alienated to private persons and corporations who have no interests to serve but their own.

Reservation of minerals on free grant lands and lands sold for agricultural purposes.

Surface rights and mining rights.

Under the system of free grants to settlers adopted in 1868 all minerals have been reserved to the Crown, and by an amendment to the Public Lands Act in 1891 they are so reserved on all lands now sold for agricultural purposes. So it has come to pass respecting those lands that two classes of rights are recognized, viz., surface rights and mineral rights. The owner of the surface rights may apply for a patent or lease of the mining rights on his lot, and his claim possesses priority except where there has been an earlier application and a deposit of at least half the purchase price or rental made, or in case of original and bona fide discovery of valuable mineral by a subsequent applicant within one month prior to the application of the owner of surface rights. In either case the price per acre of a patent or lease is one half of the rates for a mining location where surface and mining rights are not separated. But a prospector is limited in his right to go upon private land on which the minerals have been reserved to explore it. He cannot enter any portion of a lot used as a garden, orchard, vineyard, nursery, plantation or pleasure ground, or upon which are crops which may be damaged by exploring, or on which is any house, church or cemetery, except with the written consent of the owner or locatee. Neither can the person to whom mining rights have been conveyed go on the land to open it for ores or minerals until he has first agreed with the owner of surface rights for compensation and damage ; but should the parties fail to agree it is in the power of the Director of the Bureau of Mines to order and prescribe the manner in which compensation shall be ascertained and paid or secured, either by an arbitrator appointed by himself or by a suit or action in any county or district court between the parties.

Pine trees reserved to the Crown, but owner or lessee of a location may cut and use for certain purposes.

Exemption in case of lessee.

The important point.

It is to be observed that in all sales or leases of mining locations all pine trees thereon are reserved to the Crown, and should the locations lie within a timber limit the holder of a license to cut timber on the lands may enter upon them and cut and remove the trees. Yet although the patent or lease expressly reserves pine timber, the owner or lessee may cut and use all pine and other trees needed for building, fencing and fuel on the land, and for any purpose essential to working the mines upon it, as well as cut and dispose of all trees required to be removed in clearing the land for cultivation. But a lessee is restrained from using pine trees for fuel other than dry pine, and should he intend to clear any portion of the land for cultivation he is required to give the holder of the timber license three months' notice so that he may remove any pine on the area to be cleared. If at the end of that period it is not removed the lessee may cut and dispose of all trees on the land to be cleared, but subject to payment of the same dues as are payable by the holder of the license. The privileges of the lessee are also circumscribed in another particular. Should he during the first ten years seek to cut timber other than pine upon his location beyond what is needed for building, fencing or fuel, or in the course of actual clearing for cultivation, or for any purpose essential to the working of the mines, he must first apply for leave to the Commissioner of Crown Lands, who may grant authority to cut the timber and fix the rate of dues to be paid upon it. But inasmuch as a lessee may forfeit and abandon his title to a location by the simple process of neglecting or refusing to prepay the yearly rent, it is not reasonable that he should be treated with the same liberality as an owner in respect to the timber upon the land. The important point is however that both owner and lessee of a mining location are entitled to the free use of all the timber upon it which may be wanted for mining purposes, while the owner is entitled to the free use of all timber excepting pine upon it for any purpose. The owner or lessee of mining or underground rights has of course no claim to use of the timber upon a location which, as far as it goes at all, goes with the surface rights.

Mining claims.

The portion of the Act which relates to mining claims and the manner of acquiring, holding and working them is for the present inoperative, inasmuch as no tract of country has been declared or set apart as a mining division.

The reason no doubt is that circumstances have not arisen to call for utilizing the system for which it provides, either by reason of the distance of mining fields from surveyed or settled territory or the discovery of fields very rich in gold or other valuable ores where small areas would satisfy the desires of mining men. Mining locations are preferred, and there is not a demand for mining claims. Yet it is possible that the demand may arise in some portion of the vast mineral-bearing formations of the Province, and in view of that contingency it is well to have a provision ready at hand to which effect may be given at the will of the Executive.

Areas of mining claims.

In the Mining Act of 1864 the area of a claim which might be staked out by one person holding a license was less than half an acre and by a company of persons not more than about $2\frac{3}{7}$ acres, and these areas were doubled by the Act of 1869. The Mines Act 1892 provides for staking out by one person a claim 660 feet along a vein by 330 feet on each side of it (about 10 acres), and by a company of persons a claim not exceeding at the maximum 1,320 feet along the vein by 330 feet on each side of it (about 20 acres).

Miner's license.

But no person has the right to stake out a claim or to mine it who does not first obtain a miner's license, for which the fee is $5, and pay a year's rent for a claim at the rate of $1 per acre. A license is renewable only upon payment of the fee and of the annual rent for a claim, and the tenure of a claim depends besides on stringent working conditions. Adequate provision is made for the protection of miners' rights in a division, and for the enforcement of law and order under the authority of an Inspector.

Inspection of mines.

The fourth part of the Act is chiefly designed to provide for the health, safety and well-being of miners through a proper and careful observance of regulations for the working and management of mines; but as these follow pretty closely the British Mining Regulations any enumeration of their features would be superfluous here. The Inspector, whose duty it is to look after their enforcement, finds that owners and officers of mines are with rare exceptions desirous of doing liberally all that the regulations require, and it does not appear that the employed classes have a grievance under them for which legislation could effect a cure.

REPORT OF THE INSPECTOR OF MINES.

To the Director of the Bureau of Mines:

Sir,—I have the honor to submit herewith my third annual report on the Inspection of Mines for the Province of Ontario, being for the year 1892.

General condition of the mining industry.

Although mining operations have not been conducted throughout the Province on as broad a scale as could be desired, yet in some of the classes of minerals encouraging results may be traced, especially in gold, nickel, copper and mica.

Several of the hitherto large-producing silver mines west of Port Arthur have been closed down, not by reason of having become non-productive, but from causes which may but temporarily suspend the work. The phosphate markets have been dull, and on this account several of these valuable properties have been lying idle during the year, while others have been worked only to a limited extent.

GOLD.

In Lake-of-the-Woods region.

The Sultana and Sultana Junior mines.

The Sultana mine is situated eight miles from Rat Portage, on the Indian reserve, location X42, and is owned by Messrs. John F. Caldwell of Winnipeg, holding fifteen-sixteenths, and H. Henessy of Rat Portage, one-sixteenth. Mr. Caldwell holds the mineral claim X43 Indian reserve and B38, comprising 40 acres. Mr. W. M. Caldwell has the management of the property. A few men were at work from the beginning of the year, and in March the force was increased to 8, who had been constantly employed up to June, the date of my visit.

The place of working is near the landing or dock, and the ore is removed from the opening in wheelbarrows to the place of shipment. An open cutting has been made to the distance of 250 feet in a northeast direction, following the side of the lake, and has been worked to the depth of 15 to 18 feet, showing a width of vein of 27 feet. The lead has been traced between granite and slate a distance of about 20 chains. The lowest cutting is only 5 feet above the high-water mark of the lake. About 130 tons of ore had been mined and removed to the dock ready for shipment to the Reduction Works at Rat Portage. Other openings had been made in the property the fall previous. One which I especially noted is about 500 yards in a southerly direction from the present workings, on a steep elevation, and from which 350 tons of ore had been mined and taken to the mill at Rat Portage. A comfortable boarding-house, a blacksmith shop and convenient docks have been built. It was intended to put on additional force and use steam power for drilling and other purposes so soon as the ore could be properly treated at the mill in the town.

A force of 32 men was employed at the mine and mill at the close of the year. Mr. Margach of Rat Portage in a recent letter states that a stamp mill with rock crusher for pulverizing and Frue vanners for concentrating the ore, is in successful operation at the mine. I note also by a late communication through the papers that a fine gold brick has been turned out of the works as proof of the value of the ore and the successful method of treating it. On Sultana Junior six men were then at work.

The Northern Gold Company's mine.

The Northern Gold Company, formerly known as the Gold Hill Company, are engaged working their prospect, which is situated on the mainland twenty miles southeast of Rat Portage, and contains 906 acres held in fee simple. This discovery was made eight years ago by Mr. George Dulmage, the present superintendent of the work. D. B. Burdette of Belleville is president, and J. R. Wright is the business manager. Ten men had been employed for the past year and their number was increased to thirteen when I visited the property. The workings consist of a shaft sunk to the depth of 28 feet, with other openings following the lead for at least a mile. Shaft No. 2, the present place of working, has reached a depth of 45 feet at an angle of 45 degrees, following the mineral between well-defined walls. The vein matter is 9 feet in width, with about 3 feet of pay streak.

The Leede process adopted.

A carload of the ore taken from these workings had been sent to Minneapolis to be tested by the Leede process, and so satisfactory was the trial that an order was given for a plant to be put up at the mine, although formerly stamps and other machinery of the ordinary class for a mill had been ordered; these were abandoned. The whole of the plant for the new process was expected to arrive and be placed in position for work in a month or two. The boiler is of 40 horse power. The ore will be roasted by gas generated from petroleum, using 12 barrels daily. About 150 to 175 tons of ore were ready for treatment, and by the Leede process this ore will be reduced to bullion. A tramway is now being constructed from the mine to Moon bay, a distance of 1½ miles, which will be in use shortly. Through a reliable correspondent I am informed that 24 men were working on this property at the end of the year.

Homestake mine, on Yellow Girl bay.

The Homestake mine is on a strip of the mainland at Yellow Girl bay, about 25 miles in a southerly direction from Rat Portage, and is owned by the Homestake Company of Algoma, with capital stock of $300,000, in shares of $1 each. About 65,000 shares have been disposed of, and the proceeds are to be used for development purposes and constructing a mill at the mine.

Mr. Heldrith, a member of the company, is manager of the works, and at the time of my visit had mined about 50 tons of ore, 25 of which had been taken to the Reduction Works at Rat Portage. He had a contract to deliver 1,000 tons at Rat Portage, which he expected to accomplish at the rate of 30 tons daily. The proceeds are to be used for the further exploring and developing of the property.

A letter in January, 1893, from William Margach, Crown timber agent, states that "ten men are at work on the mine, and Messrs. Heldrith & Chadwick have a stamp mill which they propose putting in operation."

The Dead Broke mine.

The Dead Broke mine is located on P64, Red Rock island, about 22 miles in a southerly direction from Rat Portage, and is owned by Jeff. Heldrith.

Work on this mine was commenced in April last with ten men, and the vein has been stripped 50 feet in length and nearly the same in width. An open cut has been made 20 feet in length and 12 feet in width and a few feet in depth, from which about 75 tons of ore have been removed, and showing by frequent assays from $7 to $133 per ton; 25 tons of the ore have been taken to the Reduction Works to obtain a mill run. The work was interfered with by the inflow of water, and a new opening has been made at the distance of 130 feet from the former one and the tunnel has been driven in 25 feet. It is intended, I was informed, to put on an increased force and work the property on an extensive scale.

Gold Creek mine, near Pine Portage bay.

The Gold Creek mine is situated near Pine Portage bay, one mile from the point at the head of the bay. The location comprises 180 acres P347, and is owned by Messrs. E. H. Kendell, Samuel Whiting and Joseph Thompson, all of Rat Portage. The discovery was made in 1890; work was commenced with a force of seven men in the fall of 1891, and has been continually carried on under the direction of G. F. Ernst, who has had large experience as a miner and who now holds the property under lease. A vertical shaft has been sunk to the depth of 50 feet, following a vein with average width of 9 feet from the surface to the bottom of the shaft. The shaft is well timbered to a depth of 15 feet through the clay and sand, where a firm slate formation has been reached with well defined walls requiring no supports. Two test pits have been sunk, one 8 feet on a vein of 10 feet in width, and the other 16 feet deep on vein matter of 14 feet width. The vein has been followed on the surface by openings at intervals for the distance of 500 feet west, and in a southerly direction for 2,000 feet. A force of seven men was employed at the date of my visit in June.

Extent of the workings.

About 300 tons of ore had been taken out and was being conveyed by tug to the Reduction Works at Rat Portage for treatment. The place of shipment is at Heenan's point, a distance of one-third of a mile from the mine, where a convenient dock has been built. The ore which was being shipped had been taken to the dock in the winter season. A good roadway was being constructed from the mine to this dock.

A good boarding-house and shaft-house have been built, and the whole of the work in and about this mine has been done in an exceedingly neat and substantial manner.

Ontario Mining Co.

Eight miles from Rat Portage, and near Sultana island, the Ontario Mining Company own a location on which a shaft has been sunk to the depth of 50 feet, from which excellent samples of ore have been taken. The property is owned chiefly by Winnipeg capitalists.

Winnipeg Consolidated.

The Winnipeg Consolidated Gold and Smelting Company own a property on Big Stone bay, 18 miles out from Rat Portage. Several years ago this property was worked for one year. A shaft was put down 120 feet and drifts run in with such excellent results that a stamp mill was put up. The ore was of good grade.

Pine Portage mine.

The Pine Portage mine is situated one mile inland from Pine Portage bay, and about eleven miles from Rat Portage. A shaft has been sunk 120 feet and about 50 feet of drifting done. The property is regarded as valuable and a watchman resides upon it. Mr. Dobie, one of its chief owners, stated that it was probable work would be resumed during the present year.

Climax mine.

The Climax mine, owned by A. Egan of Winnipeg, is situated on Big Stone bay, about 10 miles from Rat Portage. From an open cut in the side of the hill 600 or 700 tons of ore have been raised, most of which has been taken to the Reduction Works at Rat Portage for treatment; 36 assays showed the average value of ore to be $19 per ton.

Keewatin mine.

The Keewatin mine is situated on Hay island, 10 miles from Rat Portage, one of the largest islands of Lake-of-the-Woods, which may be regarded as a lake of islands. It is owned by Good & Jones of Winnipeg.

Heenan mine.

On the Heenan mine, which is one mile south of the Keewatin, a 50 foot shaft has been sunk; it is the property of the owners of the Keewatin mine.

Boulder Island mine.

On Boulder island, containing 12 or 14 acres, a discovery was made a few years ago, a considerable amount of development work done, and a mill put up, which was afterwards moved to the Consolidated mine. The property is owned by William Gibbons and others of Winnipeg.

Fish Island mine.

On Fish island, near to Boulder, a promising discovery was made seven years ago, and the property was obtained by a company of capitalists from California and worked to a limited extent. One shaft was put down 30 feet, when the work was suspended for the same cause as on the Boulder and other properties—a disputed title.

El Diver, Caribou and Treasure mines, near Rossland station

The El Diver mine is on location P351, which comprises 80 acres and is situated 2¼ miles north from Rossland station, Canadian Pacific Railway, 8 miles east from Rat Portage. The property is owned by Messrs. J. W. Webster and E. W. Gaylord of Cleveland, Ohio. Mr. Gaylord has charge of the works at the mine.

Work was commenced in October, 1891, with a force of five men, which was increased to seven during the winter. Ten men were employed in June at the time of my inspection. The principal shaft has been sunk to a depth of 60 feet, following the vein matter from the surface with an average of two feet of pay ore. The work was being done by contract, and about 200 tons of ore were on the dump.

A mill for concentrating the ore has been erected, and the machinery would be in place and all running in about a month. The concentrates were to be treated at the Reduction Works in Rat Portage. It was intended to continue operations both at the mine and mill with a sufficient force to fully test the value of the mine, and to increase the work as the development would warrant. The owners hold the property with a view of working it, rather than as a speculation. A dwelling house with office was being constructed, and a good boarding-house and blacksmith shop have been completed. Other prospecting was being done on the property. I directed the attention of the manager to some necessary work to be done for the protection of the workmen in walling off the ladder-way in the shaft and timbering near the surface.

Mr. Webster also owns P288, comprising 80 acres, known as the Caribou, about half a mile from the station, upon which some development work has been done with excellent showing of mineral.

The last of October I received a communication from Mr. Gaylard stating that the necessary work for the safety of the mine had been properly done, also that the shaft had been continued to the depth of 75 feet, and a shaft house was being built. A friction power hoist has been purchased from the Jenkes Machine Company, Sherbrooke, Que., which will be run by rope belt from the mill. The mill building has been increased to double its size and the mill dam raised, greatly increasing the supply of water for power. The dwelling house with office have been finished, an ice-house built, and also an additional barn and stabling accommodation.

The pulvérizer which was on hand when I was there has not proved a success, and a Crawford mill has been put in in its place. It was intended, Mr. Gaylord writes, to push the work forward throughout the winter both in mine and mill if water supply and weather should permit. He also writes: "We have purchased a property two miles south of Rossland (80 acres) known as The Treasure. The ore there carries free gold in abundance at the surface; we are down about 28 feet. The showing at the bottom is not as good as at the top. The vein measures from 2 feet to 6 inches wide. We have erected several log buildings, such as boarding house, blacksmith shop, ice house, barn, magazine, etc. We intend to push the work on the shaft this winter, but shall not erect a mill before spring."

The Gold and Silver Reduction Works at Rat Portage.

About the middle of June I visited the Gold and Silver Reduction Works in the town of Rat Portage. The capital stock of the company is $200,000, with about one-half this amount paid in and used for the construction and outfit of the mill. Charles Brent has the superintendence of the work and J. P. Larkins of Rat Portage is the secretary of the company. Through the courtesy of these gentlemen I had an opportunity of carefully examining the works, and obtained through the superintendent a full explanation of the process being adopted in the extraction of the precious metal from the ore. The mill had just started up and about nine tons of ore were running through daily with the exception of being treated in the chlorination department, which was not yet fully completed. A large quantity of ore was being delivered on the dock at the mill for treatment, and it was expected a full supply would be obtained from the mines operated in the vicinity to keep the works constantly running. I forego giving an account of the mill taken at the time of my visit, as by the favor of Mr. Brent the following note has been recently received describing the process, results, changes and prospects of the Reduction Works and other mills, and the condition of several of the mines, which may be permitted insertion here as a matter of much information and interest. Mr. Brent writes :

Change of proprietorship.

"As to the Reduction Works, I regret to say that we shut down in August of last year owing to the fact that the pulverizing machinery proved useless. Our plan in brief was as follows : The ore (gold) is crushed wet to 40 mesh, the free gold extracted on plates and by pans and settlers ; the tailings from these were concentrated. The concentrates were roasted in a reverberatory furnace and treated by chlorination.

"I am glad to be able to inform you that a wealthy American syndicate has purchased the Reduction Works and will put in new and suitable machinery to properly reduce the ores of this district.

General prospects of the Lake-of-the Woods mining territory.

"As to the mines : things look very favorable at present, and if appearances are to be trusted a boom in mining will take place in the spring.

"During the fall I put in a 10-stamp mill at the Sultana, which is in successful operation and is a dividend payer. I am sorry to say however that very little has been done in the shape of mining development. The machinery consists of a hoist to bring the ore to the mill ; a 7 by 10 Blake crusher ; 10 stamps of 850 pounds each in two batteries of five stamps each, with inside copper plates and 12-foot electro-silvered copper tables. The tailings are treated by concentration over two improved Frue vanners.

"I am at present in charge of the mill at the Bulldog. We are putting in two 10-ton Crawford mills. The company is pursuing a policy of vigorous underground work and at present (50 ft) the mine looks well.

"Our next neighbors at Gold Hill have completed a new mill to be operated by the Leede process. This is a process of roasting by gas manufactured from crude petroleum, followed by amalgamation in pans, gold plates and Cook amalgamators.

"At the Treasure, south of the C. P. R. at Rossland, they are sinking with good prospects, and will put in a mill in the spring.

"At the El Diver a Crawford mill has been put in place, but they are tied up for water. They are sinking with fair prospect of success.

"The Rajah Mining Co., an English syndicate, is operating on a piece of property five miles from Rat Portage, in a northeast direction.

"The Bullion Mining Co. is sinking a shaft about five miles north of town.

"The Homestake Co. is sinking a shaft on Middle island with good showing.

"A large amount of prospecting will be done as soon as spring opens."

In the lake Superior region.

The Ogema mine is situated in the new township of Dorion, about 8 miles from Ouimet siding, C. P. R., 40 miles east of Port Arthur and 7 miles east of Pearl River station, which is the post and express office for the company.

The Ogema mine, in Dorion township.

The Ogema Mining and Smelting Company was organized under the laws of New Jersey and Ontario, with a paid up capital of $150,000. The property comprises 400 acres. Mr. John C. Smith, one of the shareholders, is manager for the company and has charge of the works at the mine. Work has been continued since September, 1891, when it was begun with a force of five men, but increased to ten at the date of my visit, June 25th. A good team is used by the company in assisting to build the Government road leading out in the direction of the mine, and hauling in machinery and supplies for the mine.

Character of the vein.

In addition to considerable surface workings a shaft of 8 by 10 feet has reached a depth of 50 feet, following the lead of galena and gold ores from the surface to the bottom. The vein is the full width of the shaft at the place of working. The sinking is still in the overflow, the formation being eruptive. The gangue consists of granite, soft trap, amethysts and quartzite, intermingled with fluor and heavy spar, and carrying numerous pockets or deposits of gold carbonates assaying as high as $668 in gold and $8 in silver. Large quantities of galena are found in the workings, some assaying 65 per cent. with $7 50 of silver. The carbonates are put in barrels and a considerable quantity of ore in the rock was lying on the dump.

The mine is provided with a good outfit for convenient and rapid working, consisting of one 15 h. p. boiler and one 12 h. p. engine, a Copeland & Bacon hoist machine, machine drills, steam pumps, etc. A pony saw-mill has also been erected to cut the lumber and fuel required at the mine.

Suitable buildings have been constructed ; shaft-house, engine-house, blacksmith's shop, cooking and sleeping camps ; also a superintendent's residence with office attached, a warehouse and stabling sheds for horses and implements, and a magazine. The mine was in a good and safe condition.

Failure of the Crawford mill to treat the ore.

In a communication received from the manager of the mine since the close of the year he informs me that the mine is still being vigorously developed, although work has been suspended for a short time on account of the extreme cold. Two shifts of men were to be put on almost immediately. In reference to the Crawford mill he writes, "Owing to the immense amount of oxide in our ores the Crawford mill did not give good results. It is a well-known fact that amalgamation is prevented by oxides, particularly that of iron. The Crawford mill however is the most perfect pulverizer and amalgamator I know of, and I believe is doing a grand work on the free milling ores at Rat Portage." He also states, "We have increasingly strong indications of a rich deposit of gold and silver."

In East Algoma and Nipissing region. — Ophir mine.

A large amount of prospect work has been done on the property known as the Ophir mine, north of Thessalon, and very excellent results obtained. Specimens of nuggets have been widely distributed among mining men. Rare specimens I learn have been forwarded for the Columbian Exposition at Chicago. The property has been acquired by a syndicate of Duluth capitalists.

The Creighton gold mine.

The Creighton gold mine is situated three-quarters of a mile from the Vermilion river, in the township of Creighton. It is being worked by an Ottawa syndicate, of which Mr. Seybold is president, and the work on the property is under the direction of J. R. Gordon, C E. Two lots, 11 in the fourth and 11 in the fifth concession, have been located and development work has been done on both. When at the mine the last of June a shaft had been sunk 50 feet at an incline of 40 degrees, following the vein from the surface. The outcropping quartz-bearing gold could easily be traced for 500 or 600 yards south, and at a width of 250 to 300 feet. The vein matter at the place of working is about 15 feet wide and contains gold of the value of $12 to $20 per ton. A 20 h. p. boiler and a 15 h. p engine are used for running the steam drill, and a Pulsometre pump discharging when operated a 2½-inch volume of water. Six or eight men were employed when I was there.

A good road has been built from the mine to the river, down which the chief supplies for the mine are brought, and a comfortable log building has been put up for boarding and lodging the men.

Balfour mine.

I visited the property of George Bennett of Chelmsford on May 30th, which is 4½ miles from Chelmsford station on the main line C. P. R., west of Sudbury 12 miles.

This property is on lot 6 of the first concession of the township of Balfour, and was being worked for gold and silver by a few men. A shaft had been put down 13 feet and drilling 35 feet from the bottom of the shaft. About 200 feet from this place another boring has been made to the depth of 35 feet. The surface formation is slate, with quartz underlying.

Assays have been made of ore taken from the surface and from the bottom of the shaft, and also from the deeper borings, showing from $2 to $8 of gold and from $1 to $5 of silver per ton. A good level road has been built from the station to the mine.

Rabbit lake location.

A gold property was located in the fall of 1891 about 20 miles east of Sudbury, 13 miles northeast of Wahnapitae station on the Canadian Pacific Railway, and 6 miles east of Wahnapitae lake near lake Kookogaming or Rabbit lake. The discovery was made in a swale, where in drift boulders free gold was found in the form of small nuggets. The property was obtained by Colonel Shaw, A. McArthur and others of Toronto, who engaged Peter McKellar of Fort William to examine and report upon the property. Mr. McKellar traced the boulders to their place of origin, a distance of only 200 feet, where several segregated veins were found. An assay test made from one of these veins by Mr. McKellar showed as high as $2,400 per ton of coarse free gold. Frequent assays showed quantity, from traces to the amount named. Other large well defined veins are found upon the same property which show free gold at the point of exposure, but are chiefly uncovered.

It is intended to prosecute further work at an early date to test the value of the property and, if satisfactory, operations will be commenced on a large scale and suitable machinery introduced for efficiently working the mine.

From the present indications Mr. McKellar, who gave me the foregoing description, regards the property as one of encouraging promise.

Nipissing mine.

A mine containing some gold and silver was discovered in 1891 by A. D. Cummings of Nipissing on the south shore of lake Nipissing, about two miles west of the mouth of South river. A limited amount of prospective work was done in the early part of the year by John McAree, P.L.S., at the instance of A. A. Wright, 273 Chestnut street, New York. The work done was in making excavations at several points on the vein and in sinking a shaft 6 by 8 feet to a depth of 35 feet. The vein is about 20 feet wide, and the gangue consists of quartz, country rock and gneiss

To fully test the value of the property Mr. McAree writes that the shaft will have to be sunk much deeper; "that there is a good strong fissure vein admits of no doubt."

In the Hastings mining region.

In May six men were engaged in working in the Carscallen shaft of the Belmont mine, in the township of that name, which had reached the depth of 100 feet, being 25 feet additional since my last report. The gangue matter contained about 15 per cent. of suphurets. At 70 feet a level has been run in a short distance, and a cross-cut shows the vein to be 15 feet in width. In the O'Neil shaft additional sinking of 10 feet has been done, making this shaft 34 feet and showing a similar grade of ore as that taken out previously. A few additional feet in depth has also been made in the Strickland shaft. The four Crawford mills set up in the village of Marmora had been run at the date mentioned to the extent of treating 220 tons of ore taken from the mine, which ore was found to be highly refractory, carrying iron and copper pyrites. The results as given to me showed a saving of 98 per cent., the assays indicating but traces of gold in the tailings not to exceed 2 per cent.

Belmont mine.

Process of treatment.

In the process of treatment the ore is passed through a Gates crusher and then introduced to the top of the mill by an automatic feeder in a continuous stream. It is there pulverized by nine balls of about 75 pounds each, which are constantly kept in rapid motion by a revolving disc which produces both a circular and lateral revolution, and by which the ore is ground to an impalpable mass, completely disintegrating the gold from the rock, which then settles into the trough or sink at the bottom of the mill and forms an amalgam with the quicksilver, which has been supplied to each mill to the extent of 125 lb. There is a constant stream of water injected into the mass at the bottom of the mill, which flowing over the disc serves the double purpose of keeping the quicksilver pure and causing an overflow about two feet above, carrying with it the pulverized silica or quartz and other impurities and leaving below the precious metal. The ore is reduced to a fineness to allow of 60 per cent. to pass through a 200 mesh, 80 per cent. to pass through a 120 mesh, and all to pass through an 80 mesh screen. The loss of quicksilver in the test run was 2 lb., the entire quantity used being 500 lb for the four mills. By the ordinary process of retort the gold was run into a brick and the standard reached 92½ per cent. of gold and a small percentage of silver.

The Crawford mill a success in treating Belmont ore.

In August, at the time of my second visit, the mine was not being operated. In a letter recently received from A. W. Carscallen, M.P., he says: "The Belmont mine is in full blast with a large Crawford mill running night and day, and a second one to be added shortly. They have about 30 men employed and everything is moving lively. The vein as it increases in depth is increasing in richness, and the outlook for this property is very bright indeed. I think the shaft is down about 120 feet, and they have started levels at 30 and 70 feet. The property is being worked by Middleton Crawford, the inventor of the mill, who is getting things in shape so that it will be a most convenient and economically-worked mine. The Crawford mills have fully come up to my expectations, and are now fairly well introduced into Ontario, both here and in the Rat Portage district, where there are three large mills at work now. A number more have been ordered for spring delivery, and the prospects are very bright for both mines and Crawford mills the coming summer. There are no other properties being worked in this section just now, but some capitalists have come in and purchased lithographic stone, and are getting ready for operations as soon as the weather gets warmer. The chances are that there will be a great boom all along the line in mining next summer in this and other sections."

Other gold property in Belmont.

T. D. Ledyard of Toronto, dealer in mines and mineral lands, writes that "gold has been found in several places on the east half of lot 19 in the first concession of Belmont. This lot is adjoining the one on which the new Belmont gold mine is situated.

Gatling mine.

The Carter-Walker process.

I have been informed that the Hastings Mining & Reduction Company have six men at work on surface ore of the Gatling mine; also that a mill is under construction at Marmora village for the treatment of ore by the Carter-Walker process, which consists in crushing and roasting the ore and forcing vaporized mercury through the pulp, which is afterwards treated in settlers.

The Crescent mine.

The Crescent mine was lying idle throughout the winter, but re-opened early in June. At the date of my inspection, August 10th, forty men were employed at the mine and mill. George McDougal had the management, with Wm. McDougal as assayer. J. N. Baker of Nova Scotia had the charge of the mill.

Work was continued on the Mackenzie shaft, which had reached a total depth of 65 feet in barren rock, crossing a vein of ore however at the depth of 50 feet.

The shaft now known as the A shaft was being worked with a few men, in contact with good ore. A considerable quantity of ore was being taken from the large open pit, where the principal work was being done.

The mine is being worked with care, and apparently it is in a safe condition for the workmen. An open pit near the mill required fencing, which the manager said would be immediately attended to. The mill had been running for only 8 or 10 days previous, and was treating about 20 tons of ore in 24 hours. For description of mine see former report.

A few tons of ore had just been treated in one of the Crawford mills, but the cleaning up had not been finished, and the results were not known when I was at the mine.

SILVER.

Murillo and St. Joseph mines.

The Murillo mine as well as the St. Joseph mine on the adjoining lot have been lying idle during the year. For description of properties, see former reports.

Beaver mine.

The Beaver mine suspended operations both in the mine and at the mill shortly after my last visit in July, 1891. A watchman has the care of the property.

Badger mine.

At my visit to the Badger mine in June a few men were employed unwatering one of the shafts and doing a small amount of work by way of refitting some of the dilapidated places. The suspension of work on this mine, so largely productive in former years, as well as the Beaver, I was informed was not for want of rich bodies of ore, but must be attributed to other causes, the chief one being the depreciation of silver. See former report.

Climax mine.

In June I examined the Climax mine, which is on mining location T 145, half a mile north of the Porcupine and about 1½ miles from Silver Creek station on the Port Arthur, Duluth & Western Railway, to which a good wagon road has been built. The property is owned by capitalists of Minneapolis and Canada, no company having yet been formed. J. H. Sinclair of Minneapolis, who resides at the property, has the entire superintendence of the works. There are two parallel veins on the property, running 30 degrees north of east and 300 feet apart. The mine has been worked constantly since the 1st of December, 1891, with a force varying from 6 to 13 men. Previous to the present owners purchasing the property some development work had been done in sinking two shafts to the depth of 34 feet each, one on each vein, and also running in a drift on the No. 1 or south vein about 80 feet. Another drift was run in on No. 2 or north vein 35 feet.

Extent of the workings.

Under the present management the level on No. 1 vein has been continued an additional 128 feet, making its total distance 208 feet and following the mineral from the place of its intersection at 50 feet from the mouth of the drift, thus opening the vein 158 feet. At a vertical depth of 31 feet from the former drift another level has been driven in 135 feet, exposing the vein for a distance of 70 feet. In the first level, at a point 50 feet from its entrance, a winze has been sunk 31 feet to intersect the level below.

On vein No. 2 the old level was continued a further distance of 40 feet, making a total of 75 feet from the entrance and following the vein the entire length. At a vertical depth of 30 feet from this level another one was driven in 213 feet, following the lead for 123 feet. There is a valuable showing of ore in this mine.

These workings are in slate formation, and the gangue consists of calc and fluor spar, quartzite, sulphide of iron and zinc blende, holding leaf and black silver, with a small portion of galena. A force of 10 men was employed.

West Silver Mountain mine.

Captain Rapsey informs me that West Silver Mountain mine has been closed since May 1st on account of the death of Mr. Drake, the owner of the property. It was expected work would be resumed so soon as the necessary arrangement could be made with the estate of the deceased. At the time work was suspended shaft No. 2 had reached a depth of 142 feet.

On the second level drifts had been extended to the distance of 364 feet west and 198 feet east. Drifting in the first level, which is 37 feet from the surface, had been continued to the extreme distance of 151 feet west, and at a point 125 feet from the shaft a winze had been sunk to the level below.

Since my last report but little work has been done in the lowest level. A considerable quantity of valuable ore had been taken out of the mine and shipped. Mr. Rapsey states in a recent letter that "the mine never looked so well as when shut down."

Gopher mine.

Discovery of the Gopher mine was made about two years ago by I. S. Roberts on the south half of lot 11 in the fourth concession of the township of Strange. The property is owned by a number of capitalists of Minneapolis, and the company formed is known as the Gopher Gold and Silver Mining Company. Capital stock, $100,000, all paid up. Mr. Howard of Minneapolis is the managing director; office, 707 Globe building. Mr. Roberts has the superintendence of the work at the mine.

Work was begun a year ago last April and continued until Christmas with from 6 to 9 men. One shaft was sunk 104 feet on a vein of 10 feet in width, and at 50 feet from the surface a drift was run in 52 feet on the vein and a cross-cut of a few feet was made. Assays from these workings show value of the ore running from $5 to $60 per ton. At a distance of 250 feet from the first, a second shaft was put down 20 feet on vein matter. No. 3 test shaft was sunk between the first and second 21 feet, in which was found a good showing of native silver.

The machinery consists of one 20 h. p. boiler, a 10 h. p. engine and a pump; but so far the pump had not been required for use.

An engine house and good dwelling house, blacksmith's shop and drying room for the men have been put up. It was expected work would be commenced again about the first of August.

Augusta mine.

Work on the Augusta mine was suspended in November, 1891. Since the former report about 60 feet of drifting has been done and a shaft 12 feet deep sunk at a distance of 130 feet from the mouth of the last drift opened. In this shaft it is said good ore was found. Mr. Griffis, the manager, informed me that the property would be worked again about the first of September.

Mines lying idle.

Silver Bluff mine was lying idle. Mr. McEwen, the manager of the Shuniah Weachu or East Silver Mountain mine, informed me that work had been discontinued at this mine October, 1891. No additional work except exploring had been done since last report. Silver Bluff, Crown Point, Silver Centre and Palisades mines were also lying idle.

Guaranty mine.

Mr. McEwen has charge of a new property known as Guaranty mine, comprising 160 acres, situated on the fourth concession of Strange, six miles east of Silver Mountain. It is owned by a company in Minneapolis; capital stock $150,000. I found 12 men employed under Captain James. A vertical shaft has been put down 45 feet on a quartz vein. Boiler and engine 16 h.p., with suitable hoist. An engine house and comfortable boarding camp have been built.

Empire mine.

The Empire mine location comprises 135 acres, being lot one in the second concession of O'Connor, and adjoining the Beaver location. Work was done as early as 1889 by sinking a test shaft 14 feet on the north part of the property. An opening was also made in the hill side on the south part of the location, opening a promising vein of ore, and a shaft was sunk 14 feet. North of this opening, 112 feet, a shaft has been sunk 16 feet deep, exposing good ore, and west of this opening another shaft has been put down 26 feet. Work has been retarded on the property on account of inflow of water. This mine gives an exhibit of very rich ore.

The property known as RXX mine is situated in the township of Scoble, comprising 80 acres. It is about 25 miles west of Port Arthur, adjoin

RXX mine.

ing Rabbit Mountain, and is owned by Joseph Brimson and R. E. Mitchell, both of Port Arthur. This mine, which is due south 1¼ miles from the famous Beaver, has been worked since November, 1891, and had a force of seven men employed when I was there. T. R. Walker of Port Arthur has the management of the work.

A vertical shaft 7 by 10 feet was sunk to the depth of 98 feet, following the vein, which is from three to four feet in width, evidently being a tracer of the Beaver vein, and showing silver which becomes richer at the bottom of the shaft. The shaft was still in the trap rock, but the slate formation was expected to be reached at an additional depth of from 15 to 20 feet. Hoisting was done by a whim. A boarding house, sleeping camp, dry house, stabling and a blackshith's shop have been erected.

Lily of the Valley mine.

Upon examination of the Lily of the Valley property, which I visited on June 14th, I found that two distinct veins of ore had been opened and traced for a distance of about 50 rods. Their course is east and west.

Starting at the farthest point east, the two veins are about 300 feet apart. The north vein runs due west and the south vein north of west, so as to form a junction with the other vein at a point 50 rods west. The first discoveries were made on the two veins nearly opposite each other, and about midway between the two extremities. A shaft was sunk on the south vein a little west of the place of discovery to the depth of 20 feet, showing the vein between well defined walls to be three feet in width. At a distance of 200 feet east of this shaft, on the same vein, another shaft has been put down to the depth of nine feet. The first five feet passed through clay, when rock consisting of spar and quartz was reached. The four feet of sinking in the rock showed the vein to a width of six feet. Work was being done in this shaft at the time of my visit.

On the north vein, which is now designated the main vein, and nearly opposite the first shaft, a third shaft has been sunk to the depth of 30 feet, exposing the vein to a width of 10 feet, but the full width had not yet been determined. The mineral has been followed from the surface to the bottom of this shaft. Work had been suspended on this shaft for two months, and it was partly filled with water. At this time about 20 tons of high grade ore had been taken from the mine.

Since writing the above, a recent note from Mr. Hugh Munroe, Crown timber agent at Port Arthur, informs me that a shaft has been sunk to a depth of 25 feet, with a showing that is really good. He states, "I saw ore that would assay $7,000 per ton."

I have been informed that the main vein has been traced by surface working a distance of three miles east and 1½ miles west.

COPPER.

Copper locations on Point Mamainse.

In the early part of June I visited a property formerly owned by the Montreal Mining Co. on Point Mamainse, which is on the east shore of lake Superior, about 60 miles in a northwesterly direction from Sault Ste. Marie, and I spent some time in examining a part of it. It consists of two locations, one known as the Sand Bay location, comprising 6,400 acres, and the other as the Pancake Point location, comprising 4,800 acres; a total of 11,200 acres. The property has passed into the hands of Detroit capitalists, who hold it by option, and they are engaged in doing development work under the direction of Captain T. H. Trethewey, who has had extensive experience in mining. It may be of interest to submit an extract or two from the report of this property, which Mr. Trethewey, after careful exploration made to Mr. H. S. Sibley, trustee, of Detroit. The description he gave is as follows:

Description of the properties.

"The formation is that of the copper bearing series, being identical with that of the Keweenaw copper-bearing rocks, and no doubt will prove a continuation of the same, consisting as it does of an enormous development of beds of alternating amygdaloid, trap, conglomerate and other allied rocks. It commences at a point on the shore of lake Superior northerly from the north boundary of Sand Bay location, and forms a chain of high hills about 3½ miles wide extending in a southeasterly direction to and beyond Pancake river, and includes also the northeasterly portion of Pancake Point location, the southerly portion being of the same formation but low and flat. The amygdaloid beds are from 3 to 20 feet thick, the trap beds from 10 to 300 feet thick, and the conglomerates range from 400 to 500 feet or more in thickness. The latter contain water-worn quartz boulders and pebbles, varying from that of coarse sand to boulders 15 inches or more in diameter. The conglomerates in which native copper occurs have not these large boulders, but are from 4 to 14 feet in thickness. The strike of these beds is from the northwest to the southeast, and they dip at an angle of 20 to 30 degrees to the southwest towards and under lake Superior, similar to the Keweenawan series on the south shore; but further inland they may be more tilted, as the beds from which I took the dip were on the lake shore.

The occurrence of copper in veins.

"Copper occurs in this region in different forms of deposit. First, in true fissure veins from three to ten feet wide, which have a north and south strike, and an easterly dip sometimes cutting the formation at an angle of 45 degrees and generally faulted, the foot wall having a lateral thrust southward. The gangue consists of earthy calcareous spar, fluor spar, druzy quartz, epidote, chlorite and brecciated fragments of the adjoining rock, in which is concentrated not only native copper but in some of these lodes copper pyrites, copper glance, green carbonate, red oxide, black oxide and native silver. Sometimes the latter is associated with the native copper; at other times it occurs on a branch of the vein entirely separate from that carrying copper. The copper glance gave by assay eight ounces of silver to the ton of 2,000 lb. Secondly, in entirely or partially filled cavities in the amygdaloid beds, and it is reasonable to expect that where the lodes intersect these copper-bearing beds rich deposits of copper will be found not only in the veins but extending for a considerable distance into the beds on each side, and following their dip, as often occurs in the copper mines on the south shore. Thirdly, in small masses and sheets lying between the trap and conglomerate beds as a cementing material, or a portion of a cementing material, occuring as a matrix in some of the conglomerates similar to that of the Calumet and Hecla mines in Michigan.

Course of the veins.

"In following the formation northward from Sand Bay location veins occur, the direction of which conincides with that of the strata; but dip at a different angle, characteristic of those of the Ontonagan districts.

"In following the trend of the strata inland, southeasterly from Sand Bay, it is found to swing round more to an easterly and westerly direction. The veins cut the formation nearly at right angles. Their course is generally marked by a deep depression through the hills similar to that of the Cliff and Central mines in Michigan. Very few outcroppings are seen, the adjoining rock and *debris* having covered them. Small creeks often follow the course of these veins. In these I have found outcroppings which generally showed native copper in small particles, as well as larger pieces up to five inches, from which I have broken specimens with the use of an axe or small pick . .

On the Huronian border.

"At the northeasterly corner of Sand Bay location, about one mile southwest from the corner post, the Huronian slates come in, having a dip to the southwest; they probably underlie the copper-bearing rocks. There quartz in veins occurs, the quartz being copper stained and likely to carry gold and silver. Granitic and syenitic rocks occur further to the northeast . .

"Sand Bay would in all probability be headquarters, where an office, boarding-house and two dwelling houses erected in 1883 are still in fair condition."

Diamond drill exploration.

These buildings were being used at the date of my visit for the convenience of the manager and the workmen. A force of ten men was employed, and during the month of May the expenditure for work and material was about $450. The principal work being done was boring with a diamond drill. Test borings had been made on four different veins, aggregating a total of 723½ feet, as follows:

No. 1, boring	82½ feet deep.
No. 2, "	110 "
No. 3, "	50 "
No. 4, "	77 "
No. 5, "	99 "
No. 6, "	123 "
No. 7, "	172 "

After the close of the year Mr. Trethewey sent on to me a further account of the work done on this property in which he states:

Sinking a deep shaft on the vein.

"As to the progress of operations in this location during the past year, I would say that in December, 1891, an exploring party was placed at work with a diamond drill to demonstrate the character of a number of veins known to exist, and which displayed favorable superficial indications. After drilling over 3,600 feet at various points, several of which showed native copper, gray and other ores, the one presenting the most encouragement was selected and it was decided to sink a shaft to fully demonstrate the strength of the vein to a depth of at least 500 feet. The drill core obtained at a depth of 41 feet contained native copper ores of considerable richness. Accordingly during the autumn of 1892 a plant of machinery necessary for the sinking of the shaft proposed was erected at the vein, including a four-drill air compressor, double cylinder steam hoisting engine, boiler, etc., since which time the shaft has reached a depth of 52 feet. For over 40 feet of this the vein has produced copper of exceptional richness, both in native copper of sheet, small mass and heavy shot form, as well as quite heavy gray ore, an assay of which yielded 34 per cent. of copper and 14.7 ounces of silver per ton. The vein also shows small quantities of native silver. It is expected that the other veins which displayed copper in the cores of the diamond drill will receive attention during the coming season, but of course the main efforts will be concentrated upon the vein which the limited amount of sinking done proves to be so richly charged with copper.

Cost of diamond drilling.

"It may be of interest to add that the cost of the diamond drilling here, which was in conglomerate, amygdaloid and trap rocks, was $1.92 per foot, which includes the entire cost of buildings, cutting roads, diamonds, etc, everything except the drill itself."

COPPER AND NICKEL.

Canadian Copper Co's. works.

Early in June when I visited the Copper Cliff mine there were about 400 men employed by the company. The new rock house had been completed and the mine was being extensively worked.

Copper Cliff mine.

The shaft in this mine, with an incline of 40 degrees, has reached a depth of 700 feet, or about 500 feet vertical depth. Extensive stopes have been done near the surface and down to the first level, 58 feet from the surface. The second level is 40 feet below the first, and has been run for a considerable distance in good ore. The third level is 83 feet below the second and has been run in 100 feet. The fourth level is still 82 feet lower, in which several large stopes have been made and run in 120 feet. The fifth level, which is 65 feet below the fourth, has been run in 180 feet and several stopes made. The sixth level, at a depth of 87 feet from the one above, has been run in 250 feet, but little stoping has been done. The lowest level is 86 feet below the sixth, and has been driven in to a total distance of 360 feet and passes through a fine field of ore.

The smelters were run to their usual capacity until within two months of the end of the year, when they, with the work in the mine, were closed down.

The Evans mine.

On the 2nd of July I visited the Evans mine and found 75 men employed, under the efficient direction of Captain Alfred James. The shaft was 220 feet deep. Work had been extensively carried on in the open pit and the three levels below it. A considerable amount of ore was being taken out and the whole work in connection with the mine was being done in a workman-like manner and proper attention paid to the comfort and safety of the workmen. About the middle of September I again examined the mine and herewith give a more detailed description of the work, as it brings it up to a later date.

Open pit workings.

In the open pit mentioned above, work was being done by 7 men in stoping, trimming and removing rock, and scaling ground. A fine ore body was exposed in the northerly part of the pit of about 30 feet in width, and extending from the bottom to the surface. On the east side of this large excavation there is an extensive field of copper ore, carrying but little nickel. The ore in this mine is sorted into three classes and treated separately, viz: Pure nickel ore, carrying but little copper; pure copper ore, carrying but little nickel; and the nickel and copper combined. The ore is taken back on the tramcars to the hoist shaft and raised to the rock house. Work will be continued in this open pit.

Second level.

A second level, which is 40 feet below the first, has been run in north 100 feet, in which large stopes have been made extending upward to within 20 feet of the floor of the first level. A large centre pillar of ore and side pillars have been left to support the roof of this part of the level. Another drift south has been run in 30 feet, in which stoping has been done, commencing at the shaft and extending back some 20 feet, leaving the opening about 12 feet wide and 12 feet high. The remaining part of this drift is in lean ore or barren rock.

Third level.

Forty-eight feet below the level No. 2 a third level has been run in north 100 feet. Extensive stoping has been done extending 40 feet in width and 30 feet in height, or within 18 feet of the floor of level 2. Three pillars of ore are left as supports in this working. A large body of ore remains in sight in this drift. A south drift has also been run in for 50 feet and an extensive stope made 30 feet wide and 30 feet high, being arched over in the centre for support.

Fourth level.

Level No. 4 is down 57 feet below No. 3. A north drift has been run in 40 feet, and but little stoping done. A south drift on the same level is run in 20 feet, with considerable overhead stoping done. There is a fine showing of ore in this drift.

Fifth level.

The shaft has been sunk to the total vertical depth of 270 feet, and a fifth level run in which is 50 feet below the fourth. Work in this level consists of a north drift extending 18 feet, with stoping just commenced. A south drift has also been driven in 18 feet. A pump has been put in this level of sufficient capacity to lift 150 gallons of water per minute to the reservoir in the third level, at which place another pump of equal capacity makes the water discharge at the surface.

Machinery.

Drilling is done principally by machinery. The Rand air compressor operates the drills and is capable of running seven. The double machine has capacity to run fourteen drills. About 120 tons of ore are taken out in 24 hours. The ore, when sorted, crushed and screened, is conveyed by railway to the roast beds near the smelters at the Copper Cliff mine. There are two boilers of 50 h. p. each and two of 70 h. p. Three are in constant use and one is held in reserve. The hoisting engine is 150 h. p. and two drums attached. The hoisting is done exclusively on the day shift. Two men are usually employed during the night in putting everything in proper shape for work in the morning. The crushing engine is 50 h. p.

Buildings.

The buildings consist of a shaft and rock house, engine-room and boiler-house, changing-house, blacksmith shop, office and warehouse. A boarding-house is conveniently arranged with 18 sleeping apartments and a large sitting-room. Three double frame dwellings with five other residences have been provided for the workmen. I gave direction that a frame that could be temporarily removed when necessary should be placed around the engine and belting in the rock-house.

About 1,800 cords of wood were on hand, obtained from the timber near the mine.

School accomodations for the children are obtained at Copper Cliff, where a good school is maintained. A Sunday school and religious services are conducted on Sabbaths in the large dining-hall of the boarding-house. Daily mails come to Copper Cliff, a mile distant.

The Stobie mine.

In the latter part of June I examined the Stobie mine, when a force of 36 men were employed under Captain Bluett. Work in the open pit was being vigorously carried on, which is now about 85 by 100 feet at the surface and has reached a depth of 70 feet, narrowing as it goes down to the present place of working. The work will continue both in stoping and sinking in this pit, from which about 100 tons of ore are being lifted daily. The adit level, 6 by 8 feet, has been run in 85 feet in a southwest direction, with a large stoping at the entrance. As the rock formation is firm no timbering is required.

Machinery.

Two steam drills were in use, one in the open cutting and the other in the drift. In addition to these, three air compressor Ingersoll drills are used. The hoist is a steam derrick. The bucket holding 1,200 lb. of ore is dumped into a car and run out on a tramway 120 feet to the rock-house. It passes into the Blake crusher, which is capable of crushing 150 tons in ten hours. It is then screened and the three grades, fine, raggins and coarse, taken to the roast beds at Copper Cliff for calcining, a distance of nine miles. About six cars are loaded daily, being about two-thirds of the entire quantity of ore treated in the two smelters. Three 20 h. p. boilers and engines are used separately for running the drills, hoisting the ore, and crushing and screening it.

Exploiting the ore body.

In addition to the large body exposed, the ore has materially improved in the percentage of nickel. The deposit of ore has been traced along the rise and top of the hill in a southwest direction for a distance of 500 or 600 feet. Several test openings have been made along the lead passing through the gossan, showing fine bodies of nickel ore.

A large quantity of wood is collected at this point and three cars, say about 37 cords, are taken daily to the roast beds and Copper Cliff mine.

Buildings.

Besides a comfortable residence for Captain Bluett and family, there has been erected a good boarding-house and all other suitable buildings for the work.

The whole is under the general management of Mr. John D. Evans, who resides at Copper Cliff.

The workings at the mine present a neat and safe appearance, with the exception of a projecting rock over the mouth of the adit which I directed should be removed.

Progress of operations.

In September when I again visited the mine the workings in the open cut had been extended westward under the hill to a distance of 30 feet from the perpendicular wall and to the length of 70 feet. As the work would be extended in this direction it would be necessary to leave substantial pillars of ore to support the rock roof. On the east side of the large opening a skip roadway was being cut through the rock, over which the ore could be taken out of the mine and conveyed to the new rock-house which was then being constructed by the side of the railway track. The southwest drift has been extended to the distance of 172 feet from the entrance and running in the direction to reach the ore bodies as shown on the surface, as described before. Apparently there is an extensive field of ore in the mine, and of much richer quality than that obtained in the earlier working of the property. A new engine-house had been built and two new boilers set up of 75 h p. each, with the engines which are intended to give the motor power for all the machinery at the mine.

A recent note from the captain of the mine informs me that the drift has been extended and a raise made opening the ore bodies on the hill.

H. H. Vivian Company.

The Murray mine.

I inspected the Murray mine (property of the H. H. Vivian Co) on the 28th of June. It had not been worked from the middle of October last to the end of April. The southwest drift in shaft No. 6, at a depth of 60 feet from the surface, had been run in the entire distance of 165 feet, and large stopes had been made in it. Due west of the shaft 35 feet, a winze was being sunk to reach the level below, which was 20 feet deep. The northeast drift had been extended to the entire distance of 250 feet, in which extensive stoping had been done. The north drift at the bottom of the shaft, which is 100 feet deep, had reached the distance of 35 feet, and the small drift mentioned in the former report starting from about the middle of this drift had been run in 35 feet. Another shaft had been started on the opposite side of the railway track at a distance of 400 feet from the former one, in a northwest direction, and had reached the depth of 25 feet.

Extension of mining work.

Work of the smelting furnaces.

The two smelting furnaces, of 50 tons capacity each in 24 hours, were running about 45 tons of good ore daily. The coarse matte produced from the ore is bessemerized and shipped to Swansea, Wales. As shipped the matte is raised to about 40 per cent. nickel and 20 per cent. copper. About four car loads of 15 tons each of Pennsylvania coke was being used weekly, or about eight tons daily. With duty and freight combined it can be laid down more cheaply than the Nova Scotia coke. Cars are loaded at the coke ovens in Pennsylvania and unloaded in the coke house at the mine.

Bessemerizing the matte.

Three boilers and three engines aggregating 100 h. p. were in use, one of 60 h. p. and the others of less capacity. The largest one is used for injecting the air through the metal in bessemerizing it, a process which occupies an hour and a half for each charge of two tons. It is then emptied out into pots where the nickel settles to the bottom and leaves the slag on the top, and when cooled in the pots and taken out the slag is easily broken from the metal. About one-quarter ton of fine matte is contained in each pot. A sufficient supply of ore was on hand to keep the smelters running for three months.

Cordwood fuel.

I was informed that 5,000 cords of wood are consumed annually in the smelting department, including the roasting. An area of 500 acres of wood land is cleared annually to supply this department of the work. The rapid consumption of wood will at not a distant date place these mining companies dependent upon the C. P. R. for bringing in fuel.

Management.

Mr. Harry Edwards has the full charge of the smelting department, in which about 70 men were employed. Mr. H. Lidgey, of Swansea, Wales, is general manager, having recently removed with his family to the mine.

September inspection.

In September I was again at the mine and examined the whole of the underground workings. Percy McNulty, the foreman, had under his charge 30 men who were divided into day and night shifts. Work was being carried on extensively in the first level of shaft No. 6, and in the lower level a small force was working in excellent ore. About 75 tons of ore were taken out daily, and when sorted about 60 tons were fitted to go to the roast heaps. A good rock-house was built and a 10 h. p. engine was used for hoist. Four air compressor drills were in use. The shaft was neatly and substantially timbered and a convenient ladder-way of 12 feet rests extended to the bottom of the shaft. I gave direction that this should be properly walled off from the part of the shaft in which the hoist cage was used.

In the smelting department a new furnace, specially designed by Mr. Edwards to meet the need of the ore and the work, of 140 tons capacity in 24 hours, has been put up and it was expected to be in operation in about ten days.

When the present smelters are continuously running about 60 tons of ore are treated in 24 hours On account of the short water supply previously there had been a temporary suspension of smelting, but the furnaces were running to the full capacity at this date. The bessemerizing process was satisfactorily continued, raising the standard of the matte for shipment to 40 per cent. nickel and from 20 to 25 per cent. copper.

A new and convenient office has been built at the smelter, together with a shop for repairs containing lathe, drill, etc. ; also a new coke house of 500 tons capacity.

Improvements.

An important improvement has been made in the tramway which leads out to the roast beds, in providing suitable turntables at each branch track whereby the ore can be dumped upon the roast heaps. One turntable is used for two roast heaps, the beds being on both sides of the main track. Thirteen turntables were put in, supplying 26 roast beds. The same are used to return the roasted ore to the smelter. A convenient weighing-house is built over the tramway and all the crude ore is weighed as it is run out to the roast heaps, and the roasted ore reweighed as it is returned to the smelter.

Dominion Mineral Co.'s works.

The Blezard mine.

First inspection.

On the 27th of June a force of 170 men were employed at the Blezard mine (the Dominion Mineral Company's property), 60 of whom were doing underground work. They were chiefly engaged in removing the rock roof over the first level, and removing some of the pillars which had been left to support it. The work, although somewhat hazardous, had the advantage of being in full daylight, and was apparently being done with care. A few men were engaged in stoping in the bottom level in shaft No. 1, in which no additional sinking has been done. Shaft No. 4, or the new shaft, at a distance of about 50 feet north from the open pit, had been put down an additional 30 feet, and a 30-foot drift in a northeasterly direction had been driven in. At this time about 150 tons of ore was being taken out daily from the mine, crushed and screened, and sent to the roast beds.

Management.

Captain Robert A. McBride, formerly of the Worthington mine, had charge of the work in this mine, and Mr. Ian Cameron of Glasgow, Scotland, had the general management of the company's works, having entered upon that duty on the 15th of March last. Mr. Cameron has had large experience in mining, and he has also been engaged in refining nickel in England, Scotland and Germany.

Serious accident at the mine.

In the early part of September, in company with the Director of Mines, I revisited this mine on the occasion of the accident which resulted in the death of five men and the injury of two others, on which a special report has been made to the Commissioner of Crown Lands. On a careful inspection of the open pit where the accident occurred, the Director of Mines fully concurred with me that no further work should be done on the floor of this opening until the entire remaining roof was removed and the pillars sustaining it were taken down, excepting that part of the roof supported by the large pillar through which the shaft passes to the deeper workings of the mine, a decision which the manager of the mine himself had arrived at. This huge pillar itself, by the blasting around it, showed some places of seam or broken formation at the sides, and we ordered that firm additional supports should immediately be put in proper position to render it entirely secure. I gave written instructions as to what should be done to make the whole of the work safe, and the manager said they should be complied with at once.

State of the mine at the second inspection.

At this time no additional sinking had been done in shaft No. 1, which was something over 170 feet in depth. The floor of the open level at the place of the shaft is 69 feet from the surface. A second level at 30 feet below the floor of the open level had been run, but was in disuse. At a greater depth of 85 feet from the floor of the first level the third or bottom level was run in about 60 feet southeast, which is known as the southeast level. A large stope was made in this drift 25 feet wide, and about the same in height, in the centre of the arch. A cross-cut is run in from this drift at a distance of 45 feet from the shaft, and extending upwards. A drift on the north side of the shaft has been run in 35 feet, but no stoping done in it. A sump is placed in this drift near the shaft, and a pump to hoist the water to the surface. This was the principal place of working in the mine at that time.

In September the new shaft had reached a total depth of 95 feet. At 81 feet from the surface a drift of 16 feet had been run in, and it was intended to extend this drift to connect with the main workings near shaft No. 1. This shaft was properly timbered and a suitable frame put in for a cage hoist. It will become the main working shaft of the mine. One hundred and sixty men were employed at this date, and about 15,000 tons of ore were on hand, together with 250 tons of matte.

The Worthington mine.

The Worthington mine is also owned by the Dominion Mineral Company. Although operated to a limited extent formerly, it has had a considerable quantity of high grade ore taken out. Work had been suspended for some time, but was again resumed on a fair scale during the latter part of the year and with most encouraging results. A body of exceedingly rich ore has been discovered in one of the shafts, which is said to be the most valuable of any nickel ore found in that district in quantity. About 50 men were employed on the mine at the close of the year. The company may regard it as practicable to place smelting works at this mine at not a distant date, as large shows of ore are being opened up.

Drury Nickel Company.

Chicago nickel mine.

The Chicago nickel mine is in the township of Drury. I inspected it on the 29th of June. For further description of location see former report. The mine and works are owned by a company of capitalists in the cities of Boston and Chicago, known as the Drury Nickel Company, with Mr. R. P. Travers as president. The capital stock is $500,000, with $120,000 paid up.

Extent of the openings.

A large open cut, the principal place of working, has been extended to the full length of 300 feet on the surface, and a fine deposit of clear ore is exposed of from 14 to 15 feet in width, with diorite foot wall. The ore deposit has increased in width about 20 additional feet, but is mingled largely with rock, say about one-half good ore. The width of the open cut at the surface is 20 feet, and at the bottom, at a depth of 40 feet, it is narrowed to 14 feet. The deepest workings have reached 70 feet and are in good ore.

Machinery and smelter.

Across the ravine, about 300 feet west from the present workings, a test pit has been opened which shows fine ore. Four air-compressor drills are used in the mine, two Ingersoll and two Rand. The ore is lifted from the mine to the top of the rock house by two skips drawn by two 4 foot friction drums, which are run by a 60 h.p. engine. The ore when hoisted is dumped on the crushing floor in the top of the rock house. When screened the three sizes, fine, seconds and coarse, are dropped into chutes, under which cars holding about two tons each are carried over the trestle tramway and dumped on the roast beds. The tramway can easily be shifted from one roast bed to another.

The smelting house is a substantial structure 60 by 60 feet, with an annex 24 by 24 feet. Besides the furnace the plant consists of three converters, two blowers, one double cylinder air compressor, one 45 h p. engine, two 85 h. p. boilers and two steam pumps. A set of Cornish rolls are used for pulverizing the quartz and other materials for lining cement.

The coke house is a good building 30 by 50 feet; but there is also a good machine shop and saw-mill with shingle mill attached for manufacturing all the lumber and shingles required for the company's purposes. The laboratory, 24 by 34 feet, is well fitted up, with Mr. Fred. Edwards in charge as assayist.

Management.

Mr. R. P. Travers of Chicago was at the mine exercising a general supervision of the entire work. Captain Travers is superintendent, with Alex. Erwin as foreman. A full force of men was employed in the various departments of work.

Sheppard mine.

A new nickel mine is being opened up about two miles north of the Blezard, called the Sheppard mine, on which a force of 40 men is employed, under the direction of Mr. E H. Davies, sinking a shaft and doing other development work. A good plant is in use, consisting of a 35 h.p. boiler and engine for hoisting, running a 7-drill Rand compressor, etc.

Macdonald mine.

On lot 12 in the third concession of Denison, one and a half miles from Worthington mine and three-quarters of a mile from the railway, a property known as the Macdonald mine was worked part of the year with a force of 10 or 12 men.

Keewatin nickel property.

About one and a half miles from Keewatin, on Lake-of-the-Woods, a nickel property has been discovered, and some prospecting work has been done on it. Openings on the surface have been made to a width of 75 feet and over a length of quarter of a mile. One opening was made 8 by 20 feet and 16 feet deep, from which about 30 or 40 tons of good ore have been taken out. Four men were employed in opening the property for five or six weeks. The property is owned by six persons residing in Rat Portage and Keewatin, and comprises 56 acres held in fee simple.. Assays made by Mr. Hille of Port Arthur show the ore to be of good grade.

MICA.

Foxton's mine and works.

Messrs. James Foxton & Bros. of Sydenham are working an amber mica property on lot 5 on the eighth concession of Loughborough with a few men. The vein had been opened at different places along the surface for the distance of 500 feet, with cuts at the respective depths of 10, 20, 25 and 45 feet. The mica extends over an area of 550 by 30 feet, from which about 30 tons have been taken out. During the two weeks previous to my visit in May about one ton per day had been mined. The place of working was from 10 to 15 feet down from the surface. About half of the mica obtained from the property is in large crystals, 10 by 12 inches. It is very tough, and commands $6 per pound, while the smaller size, 2 by 4 inches. is sold at 35 cents per pound. This property is two and a half miles from Sydenham. The market is reported as dull.

The large mica property owned by the Sydenham Mining and Mica Company has been lying idle during the year.

Smith and Lacey mine.

Messrs. Smith & Lacy are still operating their mica property in the township of Effingham, county of Addington, with satisfactory returns of pure white mica.

Grant mine.

The Grant mine is situated on lots 7 and 8 in the tenth concession of Loughborough, three and a half miles from Sydenham. It had been extensively worked in former years, but was idle in May.

The Amy and Folger mine.

The Amy and Folger mine is on lot 8 on the eighth concession of Loughborough, and is worked by Messrs. Folger and Williams. Six men were employed when I was at the mine in May, with Samuel Cordick as foreman. Mr Williams has the general management of the work. One opening had been made about 75 feet in length on the surface and worked to a depth of 30 feet. This vein can be traced on the surface for 200 feet and is 6 or 7 feet wide. The mica is found in the limestone and taken out in considerable quantity. The largest size is cut to 6 by 10 inches, but the greater proportion is in smaller sizes. Four men were working in this pit. A second working was newly made at 300 feet from the former one. The surface had been opened for 30 feet and worked to a depth of 15 feet in broken formation, and the rock and mica were being removed chiefly by picks. The mica is hauled to Sydenham and sold to the Thompson, Houston Co., and is put up in the cutting works in the town.

Truesdale mine.

The Truesdale mine is on lot 8 in the third concession of Loughborough. Three men were employed, and the work had been continued for the past nine months. It gives promising returns.

terling mine.

C. I. Sterling of Kingston is operating a mica property on lot 16 of the ninth concession of Loughborough, about seven miles northeast of Sydenham. The mine had been worked for about a year and a half, but had been suspended for the three months previous to my visit. A shaft had been opened 7 by 7 feet at the surface, which widened as it went down to 18 by 18 feet at a depth of 70 feet. It is about half filled with water. During three months of last year 50 tons of 80 per cent. phosphate and 10 tons of amber mica were taken out. In the present year, up to the date of my visit in May, 10 tons of high grade phosphate and 15 tons of mica had been mined.

Mica and phosphate.

The lead has been traced for over 300 yards, and three test pits have been sunk from 15 to 20 feet in depth. In one of these pits a vein of three feet width has been opened of excellent phosphate, which will be worked as soon as the market improves. About twenty other surface openings have been made along the lead, showing phosphate and mica. Hoisting is done by horse-power. This mine is about eleven miles from Murvale station on the Kingston and Pembroke Railway, to which the phosphate is hauled for shipment. The mica is taken to the cutting works in Sydenham.

PHOSPHATE OF LIME.

Wolf lake mine and other properties in Bedford and North Crosby.

W. J. Webster of Westport owns a phosphate property on lot 28 of the eighth concession of Bedford, situated on the border of Wolf lake. The hill rises to an elevation of 280 feet, with an incline of 30 degrees. On the hill side a shaft has been run in 15 feet, tapping a vein 7 feet in width of tough amber mica. About one ton had been taken out, and it was intended to push the work vigorously. If the market improves the work will be extended on the phosphate deposits, which have a favorable showing. Mr Webster has also obtained the following phosphate properties : Lot 21 in the tenth concession of North Crosby, being a continuation of the lead on the former lot described. On lot 19 in the second concession of North Crosby development work has been done, uncovering a vein of phosphate one foot in width for a considerable distance. On lot 29 of the ninth concession of Bedford prospecting work has been done, and 10 tons of from 65 to 70 per cent. grade of phosphate taken out. Also on lot 21 of the tenth concession of North Crosby limited prospecting has been done, showing a good opening of high grade ore.

Work at the Opinicon or Rock lake mine was being still carried on under the control of Neil Cochran with a force of 25 men at the time of my visit in May. Charles Pine of Westport was acting as shipping agent. The larger

Opinicon or Rock Lake mine.

opening described in my last report at 150 feet depth has been sunk now to the depth of 225 feet. About 150 tons of 75 per cent. ore are being taken out monthly; 800 tons were on hand at the mine. A self-dumping car of one ton capacity is used in raising the ore. A new boiler and engine of 50 h.p. are now used for running the steam drills, hoisting the ore and working two pumps to keep the mine free from water. I directed that the ladderway should be placed on the west side of the pillars, which are left to sustain the hanging wall of the mine, as the workmen would then be entirely free from danger when going in and coming out of the mine; also, that an open unused pit near the roadway should be properly fenced. Otherwise the mine was in a safe and workmanlike condition.

Lake Opinicon mine in Bedford.

Lake Opinicon mine is situated in the township of Bedford, and comprises 1,750 acres. It is owned by Mr. Swift of Ottawa, W. H. Davis of Buffalo and others, but the company's organization has not yet been perfected. Eight men besides the foreman, William J. Shales, were working at the mine. It was stated to me that a large force of workmen would be put on when the company was properly organized, which was expected to be accomplished at an early date. The mine had been worked two months in the previous year, and constantly since the beginning of April last. A shaft had been put down 48 feet, and an opening made following the lead for a distance of 136 feet, varying from 2 to 25 feet in width. Eighty tons of 85 per cent. phosphate had been taken out; 45 tons were on the dock ready for shipment, and the remainder was at the mine. A boiler and engine of 30 h.p. were used for hoisting and for driving two steam drills. An engine-house, derrick, stabling and cobbing house have been built. The ladders going into the shaft were in an imperfect condition, so I gave instructions to have these properly placed, secured and walled off from the hoisting part of the shaft.

Mines lying idle.

The Foxton mine, the Concession mine, the Johnson mine, the Eagle Lake mine, the St. George Lake mine, Silver Lake mine and Crow Lake mine were all lying idle.

The Perth district in Lanark.

Mr. William Davies of Perth, a gentleman largely interested in mining operations, and a dealer in mining lands, informed me that nothing was being done in that vicinity when at his place in the last of May, except a little prospect work for mica, and that but little work would likely be done until there was a change in the market.

Coe mine.

Phosphate and mica.

Mr. Sterling owns the Coe mine on the west half of lot 5 in the ninth concession of Loughborough, near Gould lake, three and a half miles from Sydenham. This property had been extensively worked formerly. Last year's output realized 65 tons of 80 per cent. phosphate and 70 tons of second quality, besides a small quantity of excellent amber mica. The force employed was 8 men, with Mr Samuel Cordick as foreman. If markets improve, work will be resumed at once on this property for both minerals.

The Otter mines.

The Otter mines are situated on lot 9 and the east half of lot 11 in the seventh range of North Burgess, the former containing about 200 and the latter 100 acres. These properties are about eight miles from the town of Perth, to which there is a good road, and about two miles from Rideau lake, on the line of the Rideau canal connecting Kingston and Ottawa, and are owned by Messrs. Cross & Foster of Smith's Falls Formerly extensive mining had been done on these lots, aggregating 2,000 tons of 80 to 85 per cent. phosphates, which have been sent to the market, with about 250 tons now on hand at the mines ready for sale. In addition, about 100 tons of amber mica have been taken out and sold. Mining has been suspended for the last nine months of the year on account of the dull state of the phosphate market. The mineral extends over a large area on the lots, and the work, which is done by contract, has been confined chiefly to surface openings at depths of from 10 to 15 feet. As no machinery

Character of the workings.

has been used in lifting the ore or waste rock to the surface, a large amount of refuse has been left in the cuttings, and as a result, for convenience and ease these cuttings have been abandoned and new ones opened where the ore could more easily be obtained. The mineral occurs in true fissure veins, in more or less regular deposits in the veins, which are nearly vertical, and carry about one-half mineral and the remainder waste. With suitable appliances for lifting the material from the cuttings these veins may be worked to much greater depths, as there is no apparent failure of the mineral.

Rock formation.

The prevailing rocks are pyroxene, micaceous and garnetiferous gneiss, with some bands of crystalline limestones, being those in which the phosphate of lime or apatite is usually known to occur. The greater part of the rocks are covered with a thin deposit of boulders and clay. The veins vary in width from 12 feet down to a few inches.

Mica and phosphate.

On lot 9 there is a vein 10 feet wide of mica and phosphate, some of the deposits being nearly all mica, and others nearly all phosphate. Crystals of mica are obtained from 18 inches down. At some of the places where the mica is exposed it is twisted and broken so that only from 15 to 20 per cent. would be suitable for electrical purposes.

Mr. R. Brodie of Smith's Falls, through whose courtesy I have obtained the description of the Otter properties, states: "As far as I know none of the phosphate mines in the Burgess and Perth districts are being worked this winter. There is something being done at mica. I am informed that Mr. Waters of Ottawa has bought lot 13 in the sixth range of North Burgess, a mica property, and he has a gang of men at work putting in a boiler and engine and some pumping and hoisting machinery, and also laying in a supply of wood."

The superphosphate works at Smith's Falls

Mr. Brodie, manager of the Smith's Falls superphosphate works, writes me regarding them as follows: "We fitted up our sulphuric acid plant with pyrites burners the past year. We still keep the sulphur burners so that we can use either pyrites or brimstone. We have also made some additions in our buildings and machinery, and are now well equipped for grinding and manufacturing phosphates and fertilizers. Our business increases every year."

GYPSUM.

The Merritt mine.

For two months during midsummer the Merritt mine (inadvertently designated the Glenny mine in my last report) was lying idle, but at the date of my visit in December 13 men were employed in the mine and at the mill. The mill had been operated for most of the year, treating about 5 tons of calcine or 12 tons for fertilizing uses in 10 hours. It had been shut down for a couple of weeks, undergoing repairs. The workings in the mine were chiefly carried on in the old openings, and in the usual way of mining the gyysum along the tramway, filling in the open space with the waste rock and moving the tramway again up to the breast of the gypsum. The ore is removed from the mine in the same way as described in the former report.

Output of gypsum.

About 1,200 tons were taken out during the year; 200 tons have been taken to Port Colborne to be used in smelting nickel ore, but the result has not yet been determined. About 300 tons o ore were on hand in the rock house. This mine is not troubled by the inflow of water from the Grand river, the principal workings being in dry rock. Some of the timbers in the old drifts have become defective by decay, leaving parts of the mine in an unsafe condition.

State of the mine.

Mr. Glenny, who still has the charge of the mine, stated that the whole of the work would be properly renovated at the first of the year, and any portion of the timbers which were defective would be replaced by firm new supports. I directed however that on one of the drifts the repairs should be done at once, and that work should be suspended until the drift was put in a safe condition. The mining is still done by contract.

Teasdale mine.

But limited work has been done on the Teasdale property during the year. The drift has been run in 100 yards, and a large body of gypsum opened, but the inflow of water from the river has entirely suspended operations. A wind-mill has been put up over the drift and near the end to drive a pump, but so far it has not proved effective. A small shipment of plaster had been made recently to the Alabastine Company at Paris. There may be at an early date suitable machinery provided for keeping the mine free from water, and for working the large body of ore. In December when in the mine I found the drift neatly and substantially timbered. The work was under charge of Mr. Walton.

Idle mines.

The Glenny mine, which was designated the Merritt mine in the last report, has not been worked during the year.

The Mount Healey mine is still idle, as are also the Excelsior mine and mill.

Martindale mine.

An average force of six men has been working during the year in the Martindale mine, but only two men were employed in October when I inspected it. The workings were in a greatly improved condition, and considered safe at the place of working. Very extensive openings have been made in the older workings, which are not now used, and as the work advances the walls are made secure. About 500 tons of plaster have been taken out during the year. The mining is done by contract at 75 cents per ton. The mill of 10 tons daily capacity is running part of the time, grinding plaster for fertilizing purposes.

The Garland mine.

At the date of my visit to the Garland mine in December three men were employed, including Captain Wm. Smith, who has charge of the work. The force of workmen would be increased after the holidays. About 9 or 10 tons of plaster were mined and hauled out to the mouth of the drift daily The drifting had been continued to the full distance of 152 yards, and the principal place of working was near the extremity of the drift. As the ore is removed the tramway is moved nearer to the workings and the open space walled in with waste rock The interior of the mine was in a good state of repair. The defective timbers have been replaced by new supports. A shaft has also been opened near the present workings, a depth of 52 feet from the surface, which is used for going into and coming out of the mine, as well as for ventilation, which is good in the mine. I advised that a suitable space or man-hole for refuge be made in the long tramway for safety.

Improving its condition.

The ore taken from the mine is still hauled to Caledonia and ground as a fertilizer in the mill of Messrs. Hull & Olds. Several car loads of gypsum have been sold during the year, to be used in stables as a disinfectant and absorbent. The property has again passed into the possession of Mr. Nicholas Garland of Toronto, the original owner, and whose name the mine bears.

Paris mine and works.

On the 22nd of December I was at the Paris mine property, and found two men engaged in running in a new drift at a distance of 100 feet west of the old one. It had been extended about 100 feet and would reach the bed of ore at the further distance of from 50 to 75 feet. This new drift was being made through the old waste rock left in the earlier working of the mine, and was being substantially timbered and of sufficient height to work a horse or mule in hauling out the ore. This drift would be completed in about a month's time, when the work of taking out gypsum would begin. The quantity of ore taken out of the mine in the early part of the year reached 650 tons, which was ground in the company's mill at Paris for farm use. It is claimed by some that the gray is of more value as a fertilizer than the pure white plaster. The mill is chiefly supplied with ore for alabastine from the beds of white gypsum below Cayuga. Seventy-five tons however were brought from Grand Rapids, Mich., to meet the demand for

Land plaster.

Manufacture of alabas

the year. At the time of my visit about three tons were being manufactured into alabastine daily, with a force of 10 or 12 men employed in this department of the company's work. The mill has been refitted and now has a much increased capacity, and is in a good condition every way to turn out an excellent article. This is the only mill engaged in the manufacture of alabastine in the Dominion, and the third one in the world, the other two being, one at Grand Rapids, Mich., and the other in London, England. Mr. B. M. Church of Grand Rapids, who has devoted a great deal of time in perfecting the manufacture of alabastine, is president of this company. He also is the largest stockholder and managing director of the Grand Rapids Company, and he owns a half interest in the company in England. Mr. T. W. Wheeler has still the charge of the company's works at Paris, and he controls the entire operations in Canada. The demand for alabastine is rapidly increasing, as its value becomes known as a pure and wholesome article for the beautiful and substantial decoration of walls and ceilings in dwelling houses.

I was told by Mr. Wheeler that shipments during the year had been made to almost every part of the Dominion, and that a very much larger supply would be required to fill the orders for the coming year.

MINING ACCIDENTS.

Two mining accidents occurred during the year, both of which were at nickel mines in the Sudbury district.

Accident at the Evans mine.

The first of these took place at the Evans mine on the 26th of April, which resulted in serious injury to Andrew Sorin, an employe of the Canadian Copper Company. According to the statements of two fellow-workmen he was engaged as a machine helper in sending machinery down the shaft, being at the time on the fourth level, and having heedlessly stepped out into the shaft the cage came down upon him. It was found that he was badly injured in the spine, and upon the advice of his medical attendant he was sent to the hospital at Toronto for treatment. According to the statements of the men at work with him every necessary precaution was taken to prevent accident, and the usual necessary signals were given before the cage was lowered.

Serious accident at the Blezard mine.

The second accident took place at the Blezard mine of the Dominion Mineral Company on the 6th of September, and resulted in the death of five employes of the Company and the injury of two others, one slightly. The particulars of this accident are given in a special Report made to the Commissioner of Crown Lands, under the provisions of section 65 of The Mines Act 1892.

A. SLAGHT,
Inspector.

Waterford, February 22, 1893.

SPECIAL REPORT ON THE ACCIDENT AT THE BLEZARD MINE.

To the Honorable the Commissioner of Crown Lands:

Special report to the Commissioner.

Sir,—I have the honor to submit to you, in pursuance of your instructions, a special report of the accident in the Dominion Mineral Company's Blezard mine near Sudbury on Tuesday afternoon, the 6th inst., which resulted in the death of five men, crushed beneath a mass of falling rock, and the injury of two others, one seriously but not fatally, and the other slightly. The names of those who were killed are:

List of the killed and wounded.

Duncan A. McDonald, an old miner, who leaves a wife and family;

John Johanson, a Finlander, who had been in the country only a few weeks, and who leaves a wife and two children;

Thomas Faulkner, who leaves a young wife to whom he had been married but two weeks;

A. Picard, single, a French Canadian, who had worked in the section of Sudbury for some years; and

Robert McKinley, single, aged 20 years, whose relatives reside in Ireland.

Damase Cadieux was seriously injured, but not fatally. He has a family. John Brothers was slightly hurt.

The first intimation I had of the sad occurence was on receipt of a telegram from Mr. Blue, Director of the Bureau of Mines, on Thursday, 8th inst., about noon, which was as follows:

"Accident in which five men were killed and two injured at Blezard mine. Better go up at once and investigate under provisions of section sixty-five, Mines Act. Procure plan of work where accident occurred. Answer."

The following reply was sent on same date to the Director:

"Will reach Toronto about ten to-night. Please meet me at station. Shall leave next train for Sudbury."

In our short interview in Toronto the Director informed me that you were absent from the city, and that he had been unable to reach you yet by telegram, but that he would communicate to me at Sudbury any instructions you might wish to give. On my arrival at Sudbury late on Friday, I went immediately to the coroner's office and carefully examined the evidence taken at the inquest, which had been held on Wednesday, the day after the accident.

I arranged with the coroner to procure a copy of the evidence for me, which I sent to the Director for you on the Sabbath following, being the first mail after I obtained it.

Visit to the scene of the accident.

On Saturday after my arrival at Sudbury I went out to the mine and met Mr. Ian Cameron, the general manager of the company, and Robert McBride, the captain of the mine, and they accompanied me to the place of the accident in the mine. I found nothing changed in the mine after the accident, otherwise than what was necessary in removing the bodies of the unfortunate men who had been killed. A considerable part of the day was spent in examining the location of the accident and taking necessary measurements with a view to procuring a diagram or plan of the same.

After my return to town late on Saturday the following telegram came to hand from the Director:

"Procure and send down by first mail copy of evidence taken at inquest. Commissioner directs you to take all necessary and proper measures, and make special report."

Immediately I wired answer to the Director as follows:

"Visited mine to-day. Utmost facilities given to investigate. Case serious, and perhaps more satisfactory if you come up and act with me. Will forward next mail copy of all proceedings at inquest. Answer."

The answer of same date received the following day reads:

"Will await evidence and may go up Monday night."

On Monday morning I went out to the mine again and spent the forenoon in further examining the place of accident and completing measurements, which, with the aid of the tracings of the mine kept in the office, enabled me to obtain the plans accompanying this report. Before leaving the mine I decided to return on Wednesday morning following and take all necessary evidence respecting the condition of that part of the mine when the accident occurred. This date was fixed to give time for the arrival of the Director should he decide to come up. Monday afternoon was spent at the Murray mine and on my return to town late in the evening the following message came from the Director:

"I expect to leave for Sudbury to night."

Tuesday I was at Copper Cliff, but spent most of the day at the Evans mine.

Mr. Blue arrived at Sudbury late on Tuesday and on Wednesday morning we drove over to the Blezard mine and were occupied the whole day in examining the place of accident, confirming measurements and carefully inspecting the present condition of the mine, and in taking evidence of parties regarding the condition of the place when the accident occurred.

Those whose evidence was taken on the first day are the following, viz:

Ian Cameron, general manager of the works; Robert McBride, captain of the mine; Alexander Wilson, foreman; Moses Austin, underground foreman, and Michael Giroux, laborer; all employed in the service of the Dominion Mineral Company.

Late on Wednesday evening the Director and myself returned to Sudbury, and as he could not go with me to the mine on Thursday I went out alone and took the evidence of the following parties, viz: Frank Blum, laborer; Peter Wilson, miner; and Thomas James McFarlen, laborer.

The whole of the evidence taken is submitted herewith.

Summary of evidence taken at the investigation.

I carefully looked over all the discharge papers in the office for the last six months, 121 in number, and I found 14 of the number reported as leaving on account of dissatisfaction. Thirteen of these men were engaged on above ground work. Wages was in most cases of the fourteen given as the cause of dissatisfaction.

I also obtained the statement of the manager of the company regarding the professional relation of the coroner who conducted the inquest to the company, which is herewith given.

The first plan submitted will show the position of the first level of the mine before any part of the rock roof was removed.

In my report of 1890 this part of the mine is described as follows, page 13: "Shafts 1, 2 and 3 are sunk to the depth of 69 feet to the first level, from which there has been taken 50,000 tons of ore. A number of stopes have left the opening or excavation in an irregular form about 150 by 175 feet at the bottom, and extending upwards to within 18 to 22 feet of the surface. The rock roof is well supported by four large pillars of ore, No. 1, 22 by 22, No. 2, 24 by 16, No. 3, 18 by 24, and No. 4, 22 by 24." The extreme distances were taken.

I also referred to this part of the mine in the report of 1891 as follows: "The rock roof over the extensive excavation referred to in my former report has been partially removed, showing a thickness varying from 18 to 27 feet, and a good view of the interior workings can now be had from the surface, which tends to confirm the previous description and proves the safety of the work at the date of my former report."

The second tracings show the present state of this part of the mine with the extent of roof still remaining. The tracing of the place of accident shows its state as nearly as could be obtained before the rock fell. The distance from the floor of the excavation to the surface is 70 feet, with a hanging incline of 11 feet from being perpendicular. From the floor to the lowest part of the projecting rock which fell is 18 feet The length of rock cleaved off is 19 feet, and from the upper part 33 feet to surface. It stretched across the pillar in width of say 10 feet and the extreme projection was 5½ of 6 feet, which would be about the middle of the projection and in cone shape.

General conclusions.

From the information which I have been able to obtain I am inclined to the view that ordinary care was taken in looking after the safety of the mine. It is quite certain that the projecting rock which afterwards fell was considered firmly attached to the wall by the parties whose special duty it was to examine it. Foreman Alexander Wilson, a man of several years' experience in mining, was present at the blasting down of the mantel and the remaining part of pillar No 1 on Sunday previous to the accident, and after looking at it carefully himself he took the precaution to go out and get Duncan McDonald, an old miner, to inspect it also. McDonald was considered a man of good judgment, was often consulted about matters in the mine, was entrusted with the charge of a gang of men and was paid extra wages because of his superior experience as a miner. He pronounced it safe by saying they had made a good job of it. He also began work within a few hours afterwards directly beneath the projecting rock, and was there until midnight Sunday, and also worked Monday and Tuesday. Frank Blum, who worked with him that night, says in his evidence that "there was no conversation between McDonald and myself as to there being any danger, and I did not notice anything dangerous." Foreman Wilson often passed underneath the projecting rock, and was there but a few moments before it fell. The projection was in an exposed place to the light, the roof above having been removed for a great distance around, which gave the best possible opportunity to see any seam, or slip, or fault of any kind. If it had been under cover, or if any defect could have been seen, then it should have been tested by going up to it and examining it with hammer, pick or gad, or otherwise. The place where the accident occurred was in the open daylight, and from all the evidence obtained no one of the mining men who were working around spoke of it as a place of danger. The general manager of the company, Mr. Cameron, in company with Mr. McBride, the captain of the mine, spent some time in the open workings of the mine and in full view of the projecting work but a short time before the accident; they were there for the special purpose of looking over every part of the work, and were discussing plans for future operations in the mine. They did not regard the place as dangerous, and indeed were congratulating themselves upon the safe appearance of the mine.

In the evidence taken it was shown that when any projecting rock had the appearance of danger a man was lowered from the surface to test or remove the rock. This had been done repeatedly.

After the fall of the rock it could be seen that a seam or defect existed behind it, but it is by no means certain that it could have been discovered before. The presumption is that it could not have been seen, and that the defect was inherent.

I have the honor to be, Sir,
Your obedient servant,
A. SLAGHT,
Inspector.

Waterford, September 22, 1892.

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11

ONTARIO: CANADA.

THE MINES ACT 1892.

PUBLISHED BY AUTHORITY OF
HON A. S. HARDY
Commissioner of Crown Lands.

ARCHIBALD BLUE
DIRECTOR BUREAU OF MINES : TORONTO.

TORONTO
PRINTED BY WARWICK & SONS, 68 AND 70 FRONT STREET WEST.
1892.

THE MINES ACT 1892.

INFORMATION FOR APPLICANTS.

1. Mines and minerals upon land located, sold or granted within the limits of the Free Grant territory are reserved from the location and are the property of the Crown.

2. In any letters patent for lands granted under the Public Lands Act for agricultural purposes after May 4th, 1891, mines, minerals and mining rights are reserved and are constituted a property separate from the surface of the soil, unless otherwise provided in the patent or grant from the Crown.

3. Mining lands may be acquired from the Crown either by purchase or lease under The Mines Act 1892. Application should be made to the Director of the Bureau of Mines, Toronto, and should be accompanied by the purchase money or amount of first year's rental, together with the affidavits of at least two credible and disinterested parties showing that the land is unoccupied and unimproved (except by or on behalf of the applicant), and that there is no claim thereto adverse to his on the ground of occupation, improvements or otherwise. Such affidavits may be made before any Crown Lands agent, Commissioner for taking affidavits, Notary Public or Justice of the Peace, and should be in the form given hereafter.

4. All communications on official business should be addressed (prepaid) to the head of the Department, as follows :

The Honorable
The Commissioner of Crown Lands,
Toronto.

Or, if intended for the Director of the Bureau of Mines, to

Director Bureau of Mines,
Department of Crown Lands,
Toronto.

5. Each letter should relate to one subject or one parcel of land only, *the post office address should be given, and the signature distinctly written.* In every subsequent letter the number of the lot and concession and the name of the township should be repeated.

6. Where application is made for letters patent, or for lease of mining land, the applicant should give his name in full, with place of residence and occupation, so that they may be set out in the instrument ; and, in case the applicant be a married woman, the name, residence and occupation of her husband should also be given.

7. In remitting money to the Department it may be deposited to the credit of the Treasurer of Ontario in any branch of one of the following banks, viz : Canadian Bank of Commerce, Ontario Bank, Imperial Bank of Canada, Traders' Bank of Canada, Standard Bank of Canada, or Bank of Hamilton, and the draft and certificate sent by mail to the Commissioner of Crown Lands, Toronto ; or, if there be no agency of any of these banks convenient, it may be sent by post office order payable to the Treasurer of Ontario. If cheques are sent, they should be marked good, and made payable to the Treasurer of Ontario or order. The Department does not assume any risk with respect to money remitted by letter or express.

8. Section 20 of The Mines Act 1892 contemplates that the locatee on Crown Land, as well as the grantee or lessee, is entitled to compensation for injury or damage to the surface rights at the hands of the owner or lessee of the mining rights thereafter granted in respect of the same land, and it empowers the Director of Mines to order and prescribe the manner in which such compensation shall be ascertained and paid or secured. The issuing of the grant depends on the completion of the settlement duties required by

the Public Lands and Free Grants and Homesteads Acts and the Orders and Regulations made thereunder, and until these duties are performed the locatee's interest in the surface rights is not complete. In the case of ungranted lands the compensation to be paid to the locatee or purchaser for injury or damage to the surface rights shall be calculated upon the injury or damage to the annual value only of the locatee or purchaser's interest in the land, and shall be paid annually until the issue of the patent, but so long only as the locatee or purchaser shall be recognized as such by the Department of Crown Lands.

9. The form of lease of mining lands under The Mines Act 1892 is printed herewith, as are also forms of affidavits in support of application for fifteen years' exemption from royalty under section 4, sub-section 3 of The Mines Act 1892. The form of lease of mining rights differs in some details from that of mining lands, but its provisions are substantially the same. Blank forms of transfer of mining lease and of bond and agreement respecting compensation for injury to surface rights under section 20 of said Act may be had on application to the Director of the Bureau of Mines.

AFFIDAVIT IN SUPPORT OF APPLICATION FOR LAND UNDER THE MINES ACT 1892.

Ontario, } I, of the township of in the district of
District of } and I, of the township of in the district of
To Wit: } do solemnly swear :

1. That on the day of I personally visited and carefully examined lot number in the concession of the township of and at that time there was no person residing on said lot and there were no improvements thereon *(or according as the fact is)*.

2. That there was no visible trace nor indication of work having been done on said lot by any person or persons for mining or other purposes (*as the fact is*).

3. And that to the best of my knowledge and belief there is no claim to said lot by any person or persons adverse to that of the applicant, on the ground of priority of discovery of mineral thereon, or otherwise.

Sworn before me at
in the district of this
day of A.D. 18

AFFIDAVIT OF ORIGINAL DISCOVERER IN SUPPORT OF APPLICATION FOR EXEMPTION FROM ROYALTY.

Ontario,
District of } I, of the township of in the district of
To Wit: do solemnly swear :

1. That on the day of A.D. 18 I discovered valuable mineral in a vein or lode on lot number in the concession of the township of such mineral consisting of and that I have no knowledge or information of any previous discovery of valuable mineral on said lot, and verily believe that I am the original discoverer of the same.

2. That by careful examination on the ground I have ascertained that the mineral so discovered by me on said lot is

Strike out clause (*a*) or clause (*b*) as the facts require.

(*a*) on or in a vein or lode at least three miles from the nearest known mine or discovery on the same vein or lode.

Or

(*b*) in or upon a vein or lode heretofore unknown or undiscovered at a distance of at least one mile from any known or discovered mine, lode or vein.

3. That the nearest mine, vein or lode of valuable ore or mineral to the mineral so discovered by me of which I have any knowledge or information is situated on lot number in the concession of the township of

Sworn before me at the
of in the of
this day of A.D. 18 .

A Commissioner in H. C. J.

The material portions of this affidavit are to be confirmed by the declaration of two disinterested persons, stating the facts in their knowledge and their means of knowledge. It is desirable that one of the two should, where that is practicable, be an Ontario Land Surveyor.

AFFIDAVIT OF ONTARIO LAND SURVEYOR *RE* APPLICATION FOR EXEMPTION FROM ROYALTY.

Ontario,
District of
To Wit:

I, of the of in the of do solemnly swear:

1. That I am a duly qualified Ontario Land Surveyor.

2. That on the day of A.D. 18 , I visited lot number in the concession of the township of and saw the valuable ore or mineral on or in a vein or lode thereon of which one claims to be the original discoverer, such ore or mineral consisting of

3. That on said date I carefully examined the location of said ore or mineral and ascertained by actual measurement on the ground that the same is

Strike out clause (*a*) or clause (*b*) as the facts require.

(*a*) on or in a vein or lode at least three miles from the nearest known mine or discovery on the same vein or lode.

Or

(*b*) in or upon a vein or lode heretofore unknown or undiscovered at a distance of at least one mile from any other known or discovered mine, lode or vein.

4. That the nearest known mine, lode or vein of valuable ore or mineral to the said ore or mineral so discovered by said of which I have any knowledge or information is situated on lot number in the concession of the township of

Sworn before me at the
of in the of
this day of A.D. 18 .

A Commissioner in H. C. J.

The above affidavit may be used by others than surveyors in proof of claim, striking out clause 1 in such case.

LEASE OF MINING LANDS.

Province of Ontario.

Victoria, by the grace of God, of the United Kingdom of Great Britain and Ireland, Queen, defender of the faith, etc., etc., etc.
To all to whom these presents shall come. Greeting:

Know ye that in consideration of and subject to the provisoes, conditions and restrictions hereinafter contained, we have demised and leased and do hereby demise and lease unto hereinafter called the Lessee executors, administrators and assigns, all that parcel or tract of land situate, lying and being in the and Province of Ontario containing by admeasurement acres more or less, and all those mines, veins, seams, beds or deposits of mineral, ore or metal in or on or under the said lands, together with all and singular the easements, advantages and appurtenances which are now or at any time during the term hereby granted may be held, occupied or enjoyed therewith for the purpose of mining upon and under the said lands; and also with full power to the said Lessee , executors, administrators and assigns and his and their contractors, agents and workmen, to dig, sink, drive, bore. make and use excavations, pits, shafts, levels, drifts, tunnels, wells, water-courses and other works necessary for winning, raising and removing the mineral, ore or metal in or on or under the said land; and to make and construct on the said land races, drains, dams, reservoirs, roads, tramways and railways; and to erect on the said land all buildings, furnaces, roasting-beds, engines, pumps, machinery and appliances necessary for the purpose of winning, raising, treating and reducing the mineral, ore or metal in or on or under the said land and for effectually carrying on all such mining and reducing works.

To have and to hold the said land and premises with the appurtenances unto the said Lessee executors, administrators and assigns for the full end and term of ten years, to be computed from the day of . , yielding and paying therefor unto Us, Our heirs and successors in advance at the Treasury Department, Toronto, for the first year of the said term the rent or sum of
Dollars, and for each and every subsequent year in advance and at said Department the rent or sum of
Dollars of lawful money of Canada clear from all rates, taxes and assessments to which the said lands and premises are now or at any time during the said term may be subject or liable, and from all manner of deductions whatsoever, the first of such payments to be made at or before the execution and delivery of these presents, and all subsequent payments to be made in advance on or before the first day of

in each and every year thereafter, with the right of renewal of said lease for a further term of ten years at the same rental if the terms, requirements, provisions and conditions herein contained have been performed and fulfilled on the part of the said Lessee, his executors, administrators or assigns, and thereafter with the further right of renewal for a term of twenty years on such terms and conditions and with such requirements and provisions and at such rent as may be provided by law or the Regulations now in force, or which shall hereafter be made; and so from time to time the said lease may be renewed at the expiration of every twenty years; subject nevertheless to the reservations, provisoes, terms and conditions contained in The Mines Act 1892, and reserving unto Us, Our heirs and successors all pine trees standing or being on such lands as provided by sections 17 and 18 of the said Mines Act, and also saving, excepting and reserving unto Us, Our heirs and successors the free use, passage and enjoyment of, in, over and upon all navigable waters which shall or may hereafter be found on or under or be flowing through or upon any part of the said parcel or tract of land hereby demised as aforesaid and reserving also right of access to the shores of all rivers, streams and lakes for all vessels, boats and persons, together with the right to use so much of the banks thereof not exceeding one chain in depth from the water's edge as may be necessary for fishery purposes; reserving also the right to grant without compensation to any person or corporation the right of way necessary for the construction and operation of one or more railways over or across the lands herein leased without let or hindrance from the Lessee , executors, administrators or assigns where such railway or railways shall not manifestly or materially interfere with the mining operations carried on upon the said premises.

But nevertheless this lease is made upon the condition that the said Lessee , executors, administrators or assigns shall in the first seven years of the said first term of ten years expend in stripping or in opening up mines, in sinking shafts, or in other actual mining operations, the sum of Dollars, such expenditure to consist of labor actually performed by grown men at the rate of two dollars and a half per day, or of payment therefor, or for explosives or other mining material for use on the said parcel of land, and shall also observe and perform such other conditions as have been or may hereafter be prescribed by Regulations by Our Lieutenant-Governor in Council.

Provided that in default of compliance with any of the above terms, requirements, provisions and conditions, or of payment of rent as aforesaid during the said term, the land, mines and minerals, with the right of access thereto and removal therefrom, and all mining rights upon, under or connected with such parcel of land, and every clause, matter and thing herein contained shall revert to and become the property of and be vested in Us, anything herein contained to the contrary notwithstanding. But the Lessee may defeat the forfeiture by payment of the full amount of rent within ninety days from the date hereinbefore appointed for payment thereof, and unless the whole rent is paid within ninety days from the appointed day the lease shall be absolutely forfeited and void, any statute, law, usage or custom to the contrary notwithstanding, and all claims of any and every kind and description of the Lessee or executors, administrators or assigns shall after such last mentioned period forever cease and determine.

Provided however that the said Lessee , executors, administrators or assigns on the termination hereof for whatever cause and within three months may, if all claims for rent and royalty have been duly satisfied and all terms, requirements, provisions and conditions hereof have been duly fulfilled, remove from the said parcel of land all engines, tools, machinery, railway tracks and structures which he or they may have placed or erected thereon, but shall not remove or impair any supports placed in the mine nor any timbers or frame-work necessary to the use and maintenance of shafts or other approaches to the mine, or tramways and ladders within the mine, or any other article, matter or thing the removal whereof might cause the said mine to fall, cave in or give way; in default whereof such plant, machinery, tracks and structures shall be *ipso facto* forfeited.

Provided also that all ores and minerals won, raised or taken from the said land after seven years from the date hereof shall be subject to a royalty as provided by the fourth section of The Mines Act 1892, or as may or shall be imposed by any Order in Council or Regulation made thereunder or by virtue thereof, but so as not to exceed the rates imposed by the statute now in force, or which may be imposed thereunder by Order in Council or Regulation; such royalty to be payable to the Treasury Department on or before the twentieth days of April, July, October and January of each year during the period hereinbefore prescribed, or during the said term or terms or until this lease shall be cancelled, for all the mineral, ore or metal mined and removed from said land during the three months preceding the first day of the month in which the payment is to be made as aforesaid; and the Lessee , executors, administrators or assigns shall at the time of such payment transmit to the Commissioner of Crown Lands an exact and truthful statement of the amount of mineral, ore or metal removed during the three months for which such payment shall be made, verified by the statutory declaration of sel or the manager or other officer having the charge, control and direction of the works, and by such other persons or in such other way as may be required by any order, demand or regulation in that behalf; but the Commissioner shall possess the right by a duly authorized officer or agent to inspect, revise and test the correctness of such statement at any time and in such manner as may seem proper to adopt, it being understood that any errors in these respects when ascertained shall be recognised and corrected; and We do reserve and shall at all times possess, have and hold a lien upon all ore mined and on all improvements made on such premises by the Lessee , executors, administrators or assigns for any unpaid balance on account of rent or royalty.

Provided further that if the said yearly rent or any part thereof or any royalty shall be in arrear for ninety days after the same shall have become payable, whether such rent or royalty shall have been legally demanded or not, any officer or agent appointed or authorized thereto by the Commissioner of Crown Lands may enter upon the said parcel of land and seize and distrain all mineral, metals and ores actually won, raised and taken therefrom and all machinery, apparatus, tools, waggons, carriages, engines, plant and all other goods, chattels and effects whatsoever in, upon and about the said land and premises, and every distress thus made may take away, sell and dispose of, as in cases of distress for rent reserved in common leases, and out of the moneys arising thereby retain so much as shall be sufficient to satisfy the said arrears, whether of rent or royalty, which shall at the time of sale be unpaid, and all expenses incurred by him or them in respect of such seizure, distress, removal or sale, and if there be any surplus such officer shall pay the same to the said Lessee , executors, administrators or assigns; and the acceptance or receipt of rent or royalty by or on behalf of Us, after breach of any term, requirement, provision or condition herein contained, shall not be or be deemed a waiver of the right of Us or of the Commissioner of Crown Lands or other officer on Our behalf to enforce the observance of such term, requirement, provision or condition.

And upon the publication in the *Ontario Gazette* by the Commissioner of Crown Lands of a notice declaring all the right, title and interest of the Lessee , executors, administrators and assigns under these presents to have ceased, ended and determined, the same shall cease, end and determine, and these presents shall thereafter as respects any claim, right, title or interest of the Lessee , executors, administrators or assigns be to all intents and purposes void and of none effect, and the production of a copy of the *Ontario Gazette* containing a notice purporting to be signed by the Commissioner of Crown Lands declaring the lease to have ceased, ended and determined shall be conclusive evidence in all courts whatsoever of a breach of or non-compliance with the terms, requirements, provisions and conditions herein contained sufficient to authorise and sustain such declaration and of the same having been lawfully made, and that the interest created hereunder has been lawfully ended and determined, and thereupon it shall be lawful for Us, Our heirs and successors, agents or officers, or for any bailiff or other person duly authorised thereto, to enter forthwith in and upon the said land and premises hereby demised, and the same to re-possess and enjoy as fully and effectually and to all intents and purposes as if these presents had not been made, and the said Lessee , executors, administrators or assigns to expel and remove without any legal process and as effectually as the sheriff might do in case judgment in ejectment had been obtained and the proper writ or writs had been issued on such judgment, and in case of such entry and any legal proceeding taken in respect thereof the defendant or defendants in any such suit or proceeding may in addition to any other defence plead leave and license in bar thereof, and these presents shall be conclusive evidence of such leave and license by the Lessee , executors, administrators and assigns, or other the person or persons, plaintiff or plaintiffs in such proceedings for such entry or other matters complained of in such proceedings. But such determination, notice or other proceedings shall not prevent the recovery by Us in Our own name or in that of Our said Commissioner or otherwise of any rent or royalty due and unpaid by the Lessee , executors, administrators or assigns. Further, this lease is subject to the following provisoes, terms and conditions, that is to say:

1. That the said Lessee , executors, administrators or assigns shall and will pay the rent and royalty which may be payable by him or them in manner hereinafter mentioned without any deduction whatsoever.

2. And shall and will during the said term make such provision for the disposal of the earth, rock, waste or refuse of the said land that the same shall not be an inconvenience, nuisance or obstruction to any roadway, passage, river, creek or place, or to any private, public or Crown lands, or conflict with or embarrass the future operating of said mines, or in any manner occasion any public or private damage or inconvenience.

3. And shall and will as often as required during the term make and deliver to the Commissioner of Crown Lands for the time being, or any officer or agent appointed or instructed to collect, obtain or receive the same, all such true and proper plans, sections, returns and statistics of the workings and operations of the said mines (the truth and accuracy of which shall be verified by the statutory declaration of the Lessee , executors, administrators or assigns, for the time being, or the manager or other officer having the charge, control and direction of the works of the said mine, or by such other person as any order or regulation may require) as the Commissioner shall from time to time direct.

4. And shall and will during the said term make proper and reasonable compensation to the owner or owners, occupier or occupiers, or lessee or lessees from the Crown of any adjoining land in respect of any damage which may be sustained by him or them by reason of the working of the said mine or the carrying on of the works thereof, or connected therewith, other than damage caused by the roasting, smelting, reducing or treating of ores, such compensation to be determined by the Commissioner of Crown Lands or by some officer or agent authorized by him or Our Lieutenant-Governor in Council so to do.

5. And shall and will permit any Mining Inspector or other person duly authorized in that behalf with all proper or necessary assistants at all reasonable times during the said term quietly to enter into and upon the said land, mines and premises, and into all buildings erected thereon and any part thereof, and to survey and examine the state and condition thereof and of all mines thereon, and for the purpose aforesaid to descend all pits and shafts and to enter into and to use all adits, levels, galleries, drives and excavations, and to use all roads, ways, engines, ropes, machinery, gear, appliances, materials, labor and other things in and on the said land and mine which shall be by him deemed necessary, without making any compensation for the same, so nevertheless that in so doing no unnecessary interference is caused with the carrying on of the said mining works.

6. And shall and will pay all Provincial, Municipal and other taxes upon the lands so leased which may be assessed either against such lands and the improvements thereon, or the mineral, ore or metal the product thereof, or any personal property in said mines, during the continuance of this lease in the same way and to the same extent as if the land herein leased were owned in fee by the said Lessee , executors, administrators or assigns.

7. And shall and will during the said term open, use and work the said mine and premises in such manner only as is usual and customary in skilful and proper mining operations of similar character when conducted by proprietors themselves on their own lands, and shall keep and preserve the said mines and premises from all avoidable injury or damage, and also the levels, drifts, shafts, water-courses, roads, ways, works, erections and fixtures therein and thereon in good repair and condition, except such of the matters and things last aforesaid as shall from time to time be considered by the Mining Inspector or other officer properly authorized by the Commissioner of Crown Lands to inspect and report upon such matters and things to be unnecessary for the proper working of the said mine or any contiguous mine, but so that no supports placed in the mine nor any timbers or frame-work necessary to the use and maintenance of shafts or other approaches to the mine or tramways within the mine shall be removed or impaired, and in such state and condition shall and will at the end or sooner determination of the said term deliver peaceable possession thereof, and of all and singular the premises hereby demised, to Us, Our heirs and successors, or to the Commissioner of Crown Lands, or other officer authorized to receive possession thereof.

8. And that these presents and the term or terms hereby created shall not be transferred or transferable without the written consent of the Commissioner of Crown Lands, or of some officer duly authorized by him or by general regulations to give such consent, nor unless all fees on any such transfer have been paid.

9. And that the Lessee , executors, administrators or assigns may at any time during the demised term, upon the payment of all rent due and the performance and fulfilment of all other terms, requirements, provisions and conditions become the purchaser of the land hereby demised, and in any such case the sum paid for the first year's rental shall be treated as part of the purchase money.

10. And lastly that these presents and the term or terms hereby created shall be subject to all the provisions of The Mines Act 1892 applicable to lands leased thereunder, and any amendments thereof which relate or may relate to the leasing and disposal of mineral lands, and to any Regulations which may be now or hereafter in force, as if the same had been particularly expressed and set forth herein.

Given under the Great Seal of the Province of Ontario: Witness, the Honorable George Airey Kirkpatrick, Member of Our Privy Council for Canada, and Lieutenant-Governor of Our Province of Ontario.

At Toronto this day of in the year of Our Lord one thousand eight hundred and ninety- , and in the fifty- year of Her Majesty's reign.

By Command of

Secretary. *Commissioner of Croun Lands.*

CHAPTER 9.

The Mines Act 1892.

[Assented to 14th April, 1892.

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Penalty for employment of persons contrary to Act, s. 58.
Payment of Wages prohibited at Public Houses, s. 59.
Annual Report of Statistics, s. 60.
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Fencing of abandoned Mine, s. 63.
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HER MAJESTY, by and with the advice and consent of the Legislative Assembly of the Province of Ontario, enacts as follows :

1. This Act may be cited as *The Mines Act 1892.* Short title.

PART I—GENERAL PROVISIONS.

Interpretation Clauses.

2. Where the following words occur in this Act, and in Orders in Council or Regulations under it, they shall be construed in the manner hereinafter mentioned unless a contrary intention appears :— Interpretation.

1. "Mine" includes every shaft in the course of being sunk, and every adit, level and inclined plane in the Mine.

course of being driven for commencing or opening any mine, or for searching for or proving minerals, and all the shafts, levels, planes, works, machinery, tramways and sidings, both below ground and above ground, in and adjacent to a mine, and any such shaft, level and inclined plane belonging to any mine to which this Act applies, together with all rocks, soils or strata containing any ores or minerals, and all places where the work of mining may be carried on.

Mine and mining.

2. The verb "mine" and the participle "mining" shall mean and include any mode or method of working whatsoever whereby the soil or earth or any rock, stone or quartz may be disturbed, removed, carted, carried, washed, sifted, smelted, refined, crushed or otherwise dealt with for the purpose of obtaining any metal or metals therefrom, whether the same may have been previously disturbed or not.

Mining division.

3. "Mining division" shall mean and include any tract of country declared to be a mining division within this Act.

Crown lands.

4. "Crown lands" shall mean and include all crown lands, school lands or clergy lands not in the actual use or occupation of the Crown, or of any public Department of the Government of the Dominion of Canada or of this Province, or of any officer or servant thereof, and not under lease or license of occupation from the Crown or the Commissioner of Crown Lands, and as to which no adverse claim exists which is subsequently recognized by the Commissioner of Crown Lands.

Surface rights.

5. "Surface rights" shall mean lands granted, leased or located for agricultural or other purposes and in respect of which the ores, minerals and mines thereupon or under the surface thereof are by statute, the patent or lease, or otherwise, reserved to the Crown.

Mining and mineral rights.

6. "Mining rights" or "mineral rights" shall include the right to the ores, minerals and mines upon or under or connected with the surface rights.

Party wall.

7. "Party wall" shall mean a bank of earth or rock left between two excavations.

Shaft. Plan.

8. "Shaft" includes pit, and "plan" includes a map and section, and a correct copy or tracing of any original plan as so defined.

Machinery.

9. "Machinery" includes steam or other engines, boilers, furnaces, stampers or other crushing apparatus, winding or pumping gear, chains, trucks, tramways, tackle, blocks, ropes or tools, and all appliances of whatsoever kind used in or about or in connection with the mine.

Owner.

10. "Owner" when used in relation to any mine means any person or body corporate who is the immediate pro-

prietor, or lessee, or occupier of any mine, or of any part thereof, and does not include a person or body corporate who merely receives a royalty, rent or fine from a mine, or is merely the proprietor of a mine subject to any lease, grant or license for the working thereof, or is merely the owner of the soil and not interested in the minerals of the mine.

11. "Agent" when used in relation to any mine means any person having, on behalf of the owner, care or direction of any mine, or of any part thereof, and includes the words "manager" and "superintendent." **Agent.**

12. "Inspector" includes any inspector appointed under this Act, and whether for a mining division or any part thereof or for the Province. R.S.O. 1887, c. 31, s. 2; 53 V. c. 10, s. 3. **Inspector.**

ROYALTIES ON ORES OR MINERALS.

All royalties, etc., reserved by any patent repealed.

3. All royalties, taxes or duties which by any patent or patents issued prior to the 4th day of May, 1891, have been reserved, imposed or made payable upon or in respect of any ores or minerals extracted from the lands granted by such patents, and lying within this Province, are hereby repealed and abandoned; and such lands, ores and minerals shall henceforth be free and exempt from every such royalty, tax or duty; and all reservations of gold and silver mines contained in any patent issued prior to the date aforesaid, granting in fee simple land or lands situate within this Province, are hereby rescinded and made void, and all such mines in or upon such lands shall be deemed to have been granted in fee simple as part of such lands and to have passed with such lands to the subsequent and present proprietors or owners thereof in fee simple; but the provisions of this section shall not be construed to apply to lands patented under *The Free Grants and Homesteads Act.* R.S.O. 1887, c. 31, s. 3, 4.

Reservations of gold and silver mines in any patent already issued rescinded.

Royalties payable to the Crown.

4.—(1) All ores and minerals mined, wrought or taken from lands located, sold and granted or leased by the Crown on or after the 4th day of May, 1891, shall be subject to a royalty to the Crown for the use of the Province, to be reckoned at the following rates, whether such royalty be reserved in the grant, patent or lease, or not:

a. Silver, nickel, or nickel and copper, three per cent.

b. Iron ore, not exceeding two per cent.

c. All other ores, such royalty as shall be from time to time imposed by Order in Council, not exceeding three per cent.

Nevertheless it is provided that the royalty hereby reserved shall not be imposed or collected upon any ores mined, wrought or taken until after seven years from the date of the patent or lease. No higher rate of royalty shall be levied upon ores and minerals taken from land than that provided for by the statute in force at the time of the sale or lease of such land.

(2) All royalties shall be calculated upon the value of the ores or minerals at the pit's mouth, less the actual cost of labor and explosives for mining and raising the same to the surface and shall be payable at such time and times and the values shall be fixed and ascertained in such manner as shall be provided by regulation to be made by the Lieutenant-Governor in Council in that behalf. 54 V. c. 8, s. 3.

Exemption in case of original discovery.

(3) Where a prospector or explorer who originally discovers valuable ore or mineral on or in a vein or lode at least three miles from the nearest known mine or discovery on the same vein or lode, or in or upon a vein or lode theretofore unknown or undiscovered at a distance of one mile from any other known or discovered mine, lode or vein, and in the patent, grant or lease whereof such prospector or explorer is described as the original discoverer, the grantee or lessee, his executors, administrators or assigns shall be exempted from paying royalty on any part of the ore, produce or profit of such mine to the Province for a term of fifteen years, to be computed from the date of such patent, grant or lease; provided nevertheless that it shall be incumbent upon the applicant to show,

(*a*) That the discovery was made after the coming into force of this Act and that the application for a grant or lease was made to the Department within one month from the time of the alleged discovery;

(*b*) Or that the discovery was made since the 4th day of May, 1891, and that application for a grant or lease has been heretofore made to the Department or was made within one month from the coming into force of this Act.

Ores taken for experimental purposes to be free from royalties.

5. The Lieutenant-Governor in Council may by regulation provide that the ores of any mine taken or to be taken out by way of experiment and for the purpose of ascertaining the quality and value of the mineral and mine shall be free from royalty upon the recommendation of the Director of Mines. 54 V. c. 8, s. 4.

REGULATIONS.

Lieutenant-Governor in Council may make regulations *re* Arbitrators or Mining Boards.

6.—(1) The Lieutenant-Governor in Council may from time to time make such regulations as he deems necessary or expedient for the appointment of Arbitrators or Mining Boards to hear and determine appeals from the decisions of Inspectors of divisions; for the prescribing, defining and establishing the powers, duties and mode of procedure of the Arbitrators or Mining Boards; for the opening, construction, maintenance and using of roads through or over mining claims, mining locations or lands hereafter sold as mining lands; and for the opening, construction, maintenance and using of ditches, aqueducts or raceways through or over such claims, locations or lands for the conveyance and passage of water for mining purposes, and generally for the purpose of carrying out this Act; and such regulations, after publication in the *Ontario Gazette*, shall have the force and effect of law. R.S.O. 1887, c. 31, s. 35.

Regulations of Lieutenant Governor to be laid before Assembly.

(2) Any regulations made under this Act by the Lieutenant-Governor in Council shall, if made when the Legislative Assembly is sitting, be laid upon the table of the House during the then session, and if made at any other time shall be laid upon the table of the House within fifteen days from the beginning of the next session thereof. 54 V. c. 8, s. 11.

MINERALS ON CROWN LANDS.

Crown lands may be explored for mines, etc.

7. Any person or persons may explore for mines or minerals on any Crown lands, surveyed or unsurveyed, and not for the time being marked or staked out and occupied as hereinafter mentioned. R.S.O. 1887, c. 31, s. 6.

Crown lands may be sold as mining lands, etc.

8. Crown lands supposed to contain ores or minerals may be sold as mining lands, or may when situate within a mining division be occupied and worked as "mining claims" under miners' licenses, as hereinafter provided. R.S.O. 1887, c. 31, s. 7.

Mining locations.

9. Such lands so sold when situate in unsurveyed territory, or in townships surveyed into sections or lots, shall be sold in blocks to be called "mining locations." R.S.O. 1887, c. 31, s. 8.

PART II—MINING LOCATIONS.

FORM AND PRICE OF LOCATIONS.

Form and size of mining locations in territory bordering on Lakes Superior and Huron, French River, etc.

10. Mining locations under this Act shall conform to the following requirements:

1. In the unsurveyed territory within the districts of Algoma, Thunder Bay and Rainy River, and that part of the district of Nipissing which lies north of the French River, Lake Nipissing and the River Mattawa, every regular mining location shall be rectangular in shape, and the bearings of the outlines thereof shall be due north and south and due east and west astronomically; and such location shall be of one of the following dimensions, namely, eighty chains in length by forty chains in width, containing three hundred and twenty acres, or forty chains square containing one hundred and sixty acres, or forty chains in length by twenty chains in width, containing eighty acres, or twenty chains in length by twenty chains in width, containing forty acres.

When locations border on lakes and rivers in said territory.

2. Where a mining location in the unsurveyed lands in the territory aforesaid borders upon a lake or river a road allowance of one chain in width shall be reserved along the margin of the lake or river, and the width of the

location shall front on the road allowance, and the bearings of the other outlines of the location shall be due north and south and due east and west astronomically, and the location shall otherwise conform to the requirements of the preceding sub-section as nearly as the nature of the land will admit.

Proviso.

But the Commissioner of Crown Lands may, where in his opinion the public interests will not be prejudiced, specially direct that such reservation shall not be made in the case of any island or islands which contain not more than thirty acres.

When in townships in said territory surveyed in sections.

3. In the townships in the said territory surveyed or hereafter to be surveyed into sections or lots every mining location after such survey shall consist of a half, a quarter, an eighth, or a sixteenth of a section or lot as the case may be, but so that the area of any such mining location shall be not less than forty acres.

Reservation for roads

4. In all patents and leases for mining locations in the territory aforesaid there shall be a reservation for roads of five per centum of the quantity of land professed to be granted.

Locations in other unsurveyed territory.

5. In the unsurveyed lands not situate within the limits of the territory aforesaid mining locations shall be as may be defined by any Order in Council hereafter to be made. R.S.O. 1887, c. 31, s. 9; 53 V. c. 9, s. 1.

How mining locations in unsurveyed territory to be surveyed.

11. Mining locations in unsurveyed territory shall be surveyed by a Provincial Land Surveyor, and be connected with some known point in previous surveys, or with some other known point or boundary (so that the tract may be laid down on the office maps of the territory in the Department of Crown Lands), at the cost of the applicants, who shall be required to furnish with their application the surveyor's plan, field notes and description thereof, showing a survey in accordance with this Act and to the satisfaction of the Commissioner of Crown Lands. R.S.O. 1887, c. 31, s. 10.

Price of mining locations.

12.—(1) The price per acre of all Crown lands to be sold as mining lands or locations in the districts of Algoma, Thunder Bay, Rainy River and that part of the district of Nipissing which lies north of the French River, Lake Nipissing and the River Mattawa shall be:

a. If in a surveyed township and within twelve miles of any railway	$3 50
b. If within twelve miles of any railway but in unsurveyed territory	$3 00
c. All other mining lands in surveyed territory....	$3 00
d. All other mining lands in unsurveyed territory..	$2 50

(2) The price per acre of all other Crown lands sold as mining lands or locations and lying south of the aforesaid lake and rivers shall be:

a. If in a surveyed township and within twelve miles of any railway	$2 50
b. If situate elsewhere	$2 00

(3) Where any locality or territory is shown to be rich in mines and minerals the Lieutenant-Governor in Council may by regulation set apart the whole or part of such locality or territory, and may fix the price per acre at any greater sum than is hereinbefore mentioned, or may temporarily withdraw the same from sale. 54 V. c. 8, s. 1.

TENURE OF LOCATIONS.

Expenditure per acre to be made by owner.

13.—(1) The grantee and owner of any mining location or lot or parcel sold and patented under the preceding section shall, during the seven years immediately following the issue of the patent therefor, expend in stripping or in opening up mines, in sinking shafts or in other actual mining operations where the quantity contained in the patent exceeds 160 acres, $4 per acre during the first seven years; where the quantity contained in the patent is 160 acres or less, $5 per acre during the first seven years.

How expenditure may be made.

(2) The said expenditure may consist of labour actually performed by grown men at the rate of two dollars and a half per day, or of payment therefor, or for explosives or other mining material for use on the particular parcel of land.

Lands to revert to Crown.

(3) In default of such expenditure during the said period the mines and minerals, with the right of access thereto and removal therefrom, and all rights of mining upon, under or connected with any such lot or part of lot, or so much thereof as shall be owned by any person who has failed to make the expenditure in respect of the portion or parcel owned by him shall, upon the report of the Director of Mines that such expenditure has not been made, confirmed by an Order of the Lieutenant-Governor in Council, revert to, become the property of and be vested in Her Majesty, her successors and assigns, and shall cease to be the property of any other person or persons whatsoever; but the grantee or owner shall retain all his other interests in the land or soil as agricultural land distinct from the mines and minerals. 54 V. c. 8, s. 2.

Leases of mining lands authorized.

14.—(1) Instead of granting any mining lands in fee simple the same may be leased or demised for a term of ten years with the right of renewal for a further term of ten years at the same rental if the covenants and conditions have been performed and fulfilled.

Rental.

(2) Unless otherwise provided by regulation the rental for the first year shall be one dollar per acre, and thereafter the sum of twenty-five cents per acre per annum, payable in advance, in respect of the lands or within the territory designated in the first sub-section of section 12 of this Act; and sixty cents per acre the first year, and thereafter fifteen cents per acre per annum, payable in advance, for lands situate elsewhere.

Renewal of lease.

(3) Such lease may at the expiration of the second term, if the covenants and conditions thereof have been performed and fulfilled, be renewed for a term of twenty years on such con-

ditions and at such rent as the regulations shall provide, and so on from time to time the same may be renewed at the expiration of every twenty years.

Conditions of lease.

(4) Every such lease shall be subject to such covenants and conditions on the part of the lessee, his executors, administrators and assigns, to be paid, observed and performed, as shall be provided by regulation.

Removal of machinery on expiry of lease.

(5) The said lease may among other things provide for the removal of any mining plant and machinery which the lessee, his executors, heirs and administrators shall have placed or erected upon the said premises, in case of forfeiture or non-renewal of the lease.

Expenditure upon lands leased.

(6) There shall be expended in stripping or in opening up mines or in sinking shafts or in other actual mining operations the same sum upon lands leased under the provisions of this Act as it is provided shall be expended in the case of sales or grants by section 13 hereof, and within the same time and in default of such expenditure the lease shall be forfeited and become absolutely void, and the said lands, mines and minerals shall, upon the report of the Director of Mines that such expenditure has not been made, confirmed by an Order of the Lieutenant-Governor in Council, revert to and become the property of and be vested in Her Majesty, her successors and assigns, and shall cease to be the property of any other person or persons whatsoever. 54 V. c. 8, s. 5.

When lessee may become purchaser.

15. The lessee may at any time during the demised term, upon the payment of all rent due and the performance and fulfilment of all other covenants and conditions, become the purchaser of the lands demised to him, and in such case the sum paid for the first year's rental shall be treated as part of the purchase money. 54 V. c. 8, s. 6.

Forfeiture of leases on non-payment of rent.

16. If default is made by the lessee in the payment of rent the lease shall be forfeited and become absolutely void, but the lessee may defeat the forfeiture by payment of the full amount of rent within ninety days from the date hereinbefore appointed for payment thereof ; but unless the whole of the rent is paid within ninety days from the appointed day the lease shall be absolutely forfeited and void, any statute, law, usage or custom to the contrary notwithstanding, and all claims of any and every kind of the lessee or his assigns shall from and after such last mentioned period forever cease and determine. 54 V. c. 8, s. 7

RESERVATION OF TIMBER.

Pine trees reserved.

17.—(1) The patents for all Crown lands sold as mining lands shall contain a reservation of all pine trees standing or being on the said lands, which pine trees shall continue to be the property of Her Majesty, and any person now or hereafter holding a license to cut timber or sawlogs on such lands may at all times during the continuance of the license enter upon such lands and cut and remove such trees and make all necessary roads for that purpose.

Patentees may use timber for building, fencing, etc., on the land.

(2) The patentees or those claiming under them (except patentees of mining rights hereinafter mentioned) may cut and use such trees as may be necessary for the purpose of building, fencing and fuel on the land so patented, or for any other purpose essential to the working of the mines thereon, and may also cut and dispose of all trees required to be removed in actually clearing the land for cultivation.

Timber cut to be subject to dues.

(3) No pine trees, except for the said necessary building, fencing and fuel, or other purpose essential to the working of the mine, shall be cut beyond the limit of such actual clearing; and all pine trees so cut and disposed of, except for the said necessary building, fencing and fuel, or other purpose aforesaid, shall be subject to the payment of the same dues as are at the time payable by the holders of licenses to cut timber or sawlogs. R.S.O. 1887, c. 31, s. 12.

Application of section 17 to leases.

18.—(1) The preceding section shall apply to all leases issued under this Act, other than leases of mining rights hereinafter mentioned, with the following limitations and variations, that is to say—

(2) No pine trees shall be used for fuel other than dry pine trees, and (except for domestic or household purposes) only after the sanction of the timber licensee or the Department of Crown Lands is obtained.

(3) In case it is intended to clear for cultivation any portion of the lands so leased it shall be the duty of the lessee to give the holder of the timber license three months' notice in writing of his intention to clear, and the area intended to be cleared, and its position, so that such timber licensee may remove any timber on the area intended to be cleared.

(4) If at the expiry of the time limited by the notice such timber shall not have been removed from the area intended to be cleared, then the lessee shall be at liberty to cut and dispose of all trees required to be removed in actually clearing for cultivation the area specified in such notice, and all trees so cut and disposed of shall be subject to the payment of the same dues as are at the time payable by the holders of licenses.

(6) If during the first ten years it is sought to cut timber, other than pine, on the lands so leased, beyond what is required for building, fencing or fuel, or in the course of actual clearing for cultivation, or for any other purpose essential to the working of the mines as hereinbefore provided, application shall first be made to the Commissioner of Crown Lands, who may grant authority to cut such timber and fix the rate of dues to be paid thereon. 54 V. c. 8, s. 8.

SURFACE RIGHTS AND MINING RIGHTS.

Owner of surface rights to have priority in respect of mining rights.

19.—(1) Where the mines, minerals and mining rights are reserved to the Crown the owner of any surface rights (if

Exception.

a patent or mining lease of the mining rights thereupon or thereunder has not been previously applied for, and a deposit of at least half the purchase price or rental made) may make application and shall have priority in respect of such application for a mining lease or grant thereof upon payment to the Department of the purchase money or rent within one month from the time of such application, unless in the case of original and *bona fide* discovery by a subsequent applicant of valuable mineral in or upon said premises within one month prior to the application of said owner.

Price, or rental.

(2) The price per acre of a patent or lease of mining rights shall be fifty per cent. of the rates as fixed by the twelfth and fourteenth sections of this Act respectively for a patent or lease of mining lands.

How compensation to owner of surface rights shall be ascertained.

20.—(1) Where the surface rights have been granted leased or located, and a patent or lease of mining rights shall thereafter be granted in respect of the same land, in the event of the parties failing to agree upon compensation for injury or damage to the surface rights either in the form of a specified interest in the mineral rights or ore or mineral, to be secured to the owner of the surface rights, or by payment or agreement to pay in money, or the giving of security, the Director of Mines shall order and prescribe the manner in which compensation for the damage or injury to the surface and surface rights shall be ascertained, paid or secured.

(2) For the purposes aforesaid the Director of Mines is empowered to appoint a valuator or valuators, arbitrator or arbitrators, who shall have all the powers for the purposes for which he or they shall be appointed of an arbitrator or arbitrators under any Act of the Legislature, or he may direct that such compensation shall be ascertained by suit or action in any county or district court.

Right of entry to prospect limited.

21. No person shall have the right of entry as prospector or explorer upon the surface rights of that portion of any lot used as a garden, orchard, vineyard, nursery, plantation or pleasure ground, or upon which crops that may be damaged by such entry are growing, or on which is situated any spring, artificial reservoir, dam or waterworks, or any dwelling-house, out-house, manufactory, public building, church or cemetery, unless with the written consent of the owner, lessee or locatee, or of the person in whom the legal estate therein is vested.

BUREAU OF MINES.

Appointment of Director.

22. There shall be established in connection with the Department of Crown Lands a Bureau of Mines to aid in promoting the mining interests of the Province, and the Lieutenant-Governor in Council may appoint an officer to be known as Director of the Bureau of Mines, who shall act under the direction of the Commissioner of Crown Lands, unless and till otherwise ordered, and who shall be paid such salary as shall be voted by the Legislature. 54 V. c. 8, s. 9.

23. The Director of the Bureau of Mines shall have all the powers, rights and authority throughout the Province which an Inspector or local agent has or may exercise in any mining division or locality, and such other powers, rights and authority for the carrying out of the provisions of this Act as shall be assigned to him by regulation for that purpose. 54 V. c. 8, s. 10.

Powers of Director.

24. The Lieutenant-Governor in Council may from time to time by Order in Council declare such tract of country as may be described in and by the Order in Council a mining division; and by any other subsequent Order or Orders in Council may from time to time extend, add to or diminish the limits of the division, or may otherwise amend or may cancel such Order in Council, and from and after the publication in the *Ontario Gazette* of such Order in Council the mining division therein mentioned and described and all mines on Crown lands situate in the division shall be subject to the provisions of this Act, and to any regulations to be made under this Act. R.S.O. 1887, c. 31, s. 13.

Mining divisions, how to be declared.

25. The Lieutenant-Governor may appoint for every mining division or for any part thereof an Inspector, who shall be an officer of the Bureau of Mines, and by Order in Council may prescribe the duties and fix the salary of such Inspector. R.S.O. 1887, c. 31, s. 14.

Appointment and powers of Inspectors of mining divisions.

26.—(1) Every Inspector shall be *ex officio* a Justice of the Peace of the county or united counties, district or districts, which a mining division comprehends or includes, in whole or in part, or in which or in any portion of which a mining division lies; and it shall not be necessary that he shall possess any property qualification whatever in order to enable him lawfully to act as such Justice of the Peace.

Inspector to be a Justice of the Peace.

(2) Every Inspector shall have jurisdiction as a Justice of the Peace over all the territory comprised within the division for which he is appointed, and shall have power to settle summarily all disputes between licensees as to the existence or forfeitures of mining claims, and the extent and boundary thereof, and as to the use of water and access thereto, and generally to settle all difficulties, matters or questions between licensees which may arise under this Act; and the decision of such Inspector, in all cases under this Act, shall be final, except where otherwise provided by this Act, or where another tribunal is appointed under the authority of this Act; and no case under this Act shall be removed into any Court by writ of *certiorari*. R.S.O. 1887, c. 31, s. 15.

Power to settle disputes between licensees.

Decision to be final.

27. No officer appointed under this Act shall, either directly or indirectly, purchase or be or become proprietor of, or interested in, any Crown lands or mining claim; and any such purchase or interest shall be void; and if an officer offends in

Officers to have no interest in mining claims, etc.

Penalty.

the premises he shall forfeit his office and the sum of $500 for every such offence, to be recovered in an action by any person who sues for the same. R.S.O. 1887, c. 31, s. 41.

Appointment of agents to sell mining lands.

28.—(1) The Lieutenant-Governor may from time to time appoint local officers or agents to receive applications for the sale of mining lands in their respective agencies and to carry out the provisions of any regulations and Orders in Council in that behalf and to supply information to intending purchasers, and they shall be paid in such manner and at such rates as the Lieutenant-Governor in Council may direct.

(2) The Lieutenant-Governor in Council may from time to time make such regulations as he deems necessary or expedient for the purpose of carrying out this section. 53 V. c. 9, s. 2.

PART III—MINING CLAIMS.

MINER'S LICENSE.

Mining licenses.

29.—(1) The Director of the Bureau of Mines may on payment to the Department of Crown Lands of a fee of $5 and of one year's rent at the rate of one dollar per acre grant to the party applying for the same a license to be called a "miner's license."

Duration, etc., of licenses.

(2) Every miner's license shall be in force for one year from the date thereof, and shall not be transferable, except with the consent of the Director of the Bureau of Mines; and only one person shall be named therein, who shall be called the licensee, and who, before the expiration of the license, or within not later than ten clear days thereafter, shall have the right to a renewal of the license by the Director of the Bureau, on payment to him of the like fee of $5, or such other sum as may then be the fee fixed by law for miner's licenses, and one dollar per acre per annum rental.

Form.

(3) A miner's license may be in the following form:—

PROVINCE OF ONTARIO.

No. (*Name of Division*) Mining Division. $

Bureau of Mines, (*Date.*) 18 .

Miner's License.

Issued to *A. B.*, in consideration of the payment of a fee of five dollars and of dollars for one year's rent of mining claim under the provisions of *The Mines Act 1892*, to be in force for one year from the date hereof.

C. D.,

Director.

R. S. O. 1887, c. 31, s. 16.

Fee on renewal of lease.

(4) A miner's license shall not be renewed until after the payment of the fee of $5 and the annual rental.

Powers of licensee under license.

30. A miner's license shall authorize the licensee personally, and not through another, to mine during one year from the date of the license, and from the date of any renewal thereof, on any mining claim marked or staked out by such licensee on Crown lands, as hereinafter provided; but any person or persons not occupying any other mining claim may be employed by the licensee to assist him in working such claim. R. S. O. 1887, c. 31, s. 17.

STAKING OUT AND HOLDING OF CLAIMS.

Licensee may mark out claim.

31. The licensee shall have the right to mark or stake out within the division mentioned in his license a mining claim on any Crown lands (not for the time being included in a mining claim occupied by another licensee), by planting a wooden or iron picket at each of the four corners thereof, or otherwise marking the same as may be directed by Order in Council, and to work the same. R. S. O. 1887, c. 31, s. 18.

Dimensions of claims.

32. Each mining claim shall be of the following dimensions namely:—

1. For one person, 660 feet along a vein or lode by 330 feet on each side thereof, measuring from the centre of the vein or lode, (ten acres more or less).
2. Companies of two or more persons who each hold a miner's license may stake out and work additional feet along a vein or lode by the above width in the proportion of 132 additional feet in length for every additional miner, not to exceed 1,330 feet in length altogether (twenty acres more or less), and may work the claim jointly. R.S.O. 1887, c. 31, s. 19.

Rules as to laying out claims.

33. Mining claims shall be laid out as far as possible uniformly and in quadrilateral and rectangular shapes, and the measurements of all such claims shall be horizontal; and the ground included in every claim shall be deemed to be bounded under the surface by lines vertical to the horizon at the ends, except that every mining claim shall include and shall authorize the licensee to work every dip, spur and angle of the vein or lode laterally to the depth to which the same can be worked with all the earth and minerals therein. R. S. O. 1887, c. 31, s. 20.

Forfeiture of claims by failure to notify Inspector.

34. Every Inspector appointed under this Act shall keep a book for the recording therein of mining claims which book shall be open to inspection by any person on payment of a fee of twenty cents; and every licensee who has marked or staked out a mining claim under this Act shall within thirty days thereafter give notice thereof in writing to the Inspector of the division, stating the name of the licensee, and indicating by some general statement therein the locality of the mining claim, and showing how and when the same was marked or staked out; and the Inspector shall thereupon forthwith record the particulars of the notice in the book; and, if the licensee fails to give notice to the Inspector within the time aforesaid the mining claim so marked or staked out shall be deemed to be forfeited and abandoned, and all right of the licensee therein to cease. R. S. O. 1887, c. 31. s. 21.

Forfeiture by allowing claim to remain unworked.

35.—(1) A mining claim shall also be deemed to be forfeited and abandoned, and all right of the licensee therein to cease, in case the annual rent thereof at the rate of $1 per acre has not been prepaid, or if the mining claim remains unworked for the space of three months after the same has been first marked or staked out as aforesaid, or if the same at any time, after the expiration of three months, remains unworked for the space of fifteen days: Provided, however, that in case it is shown to the satisfaction of the Inspector of the division, either before the expiration of the respective periods aforesaid or within fifteen days thereafter, that the non-working of such claim arose from the illness of the licensee, or other reasonable cause satisfactory to the Inspector, he may extend the time during which the mining claim may remain unworked for such further period of time as he thinks reasonable, and may in like manner thereafter, for reasonable cause established to his satisfaction, grant further extensions of the time during which the claim may remain unworked without being liable to forfeiture; and the Inspector shall forthwith enter in the said book all enlargements or extensions of the time granted by him. R.S.O 1887, c. 31, s. 22.

(2) If default is made by the licensee in the payment of rent the claim and license shall be dealt with as provided in section 16 of this Act in the case of a lease.

Exception where suspension of work ordered.

36. No mining claim within a division shall be considered unworked, within the meaning of the last section, during the time that an Order in Council directs that work on mining claims within such mining division may be suspended. R.S.O. 1877, c. 31, s. 23.

No person to occupy more than one claim.

37. No person shall occupy at the same time more than one mining claim on Crown lands, except in the cases hereinafter provided for of registration of claims rendered temporarily unworkable. R.S.O. 1887, c. 31, s. 24.

License to be exhibited to Inspector on demand.

38. Every licensee shall be held and required to produce and exhibit his license to the Inspector for the division, and to prove to the satisfaction of the Inspector that the license is in force, whenever required to do so by him. R.S.O. 1887, c. 31, s. 25.

Right of discoverer of new mine.

39. The discoverer of a new vein or lode of ore or mineral shall be entitled to two mining claims of the area prescribed by the first sub-section of section 32 of this Act. R.S.O. 1887, c. 31, s. 26.

What deemed a discovery.

40. No person shall be considered a discoverer within the terms of the foregoing section unless the place of the alleged discovery is distant, if on a known vein or lode, at least three miles from the nearest known mine or discovery on the same vein or lode. R.S.O. 1887, c. 31, s. 27.

Party walls to be left between claims, and kept clear.

Penalty.

41. A party wall of at least fifteen feet thick shall be left between adjoining claims on Crown lands, which party wall shall be used in common by all parties as a mode of access to the stream, where one exists ; and the party wall shall not be obstructed by any person throwing soil, stone or other material thereon ; and every person so obstructing the party wall shall be liable to a fine of not more than $5 and costs ; and, in default of payment of the fine and costs, to be imprisoned for any period not more than one month. R.S.O. 1887, c. 31, s. 28.

Person removing party wall to construct new mode of access to water.

42. If at any time it is found necessary or expedient to remove a party wall as aforesaid, the person so removing it shall, if required so to do, construct a new mode of access to the water in no wise more difficult as an approach than the one destroyed by the removal of the party wall, under a like penalty as provided in the next preceding section ; and in case of a removal of a party wall the minerals found therein shall belong to the owners of the adjoining claims, each of whom shall own the half next to his claim. R.S.O. 1887, c. 31, s. 29.

Crown lands licensees not to damage other claims.

Penalty.

43. No person mining upon Crown lands shall cause damage or injury to the holder of any other claim than his own by throwing earth, clay, stones or other material upon such other claim, or by causing or allowing water which may be pumped or bailed or may flow from his own claim to flow into or upon such other claim, under a penalty of not more than $5 and costs ; and, in default of payment of the fine and costs, he may be imprisoned for any period not more than one month R.S.O. 1887, c. 31, s. 30.

Provision for registration of claim rendered unworkable for a time.

44. In case a mining claim on Crown lands occupied by a licensee cannot be worked in consequence of an excess of water or other unavoidable cause, established to the satisfaction of the Inspector for the division, the Inspector shall, on the application of the licensee, and on receipt of $1, make an entry in the book to be kept by him as aforesaid of the cause or reason for the claim not being worked ; and thereupon and upon the licensee planting a wooden or iron picket as near the centre of the claim as possible, upon which is cut or painted his name or initial letters of his name, the licensee may occupy and work another mining claim ; but, in case the licensee does not return and occupy the first mentioned claim within fifteen days after the adjacent or surrounding claim or claims have been shown to be workable, he shall forfeit all right and title to the said claim. R.S.O. 1887, c. 31, s. 31.

OFFENCES AND PENALTIES.

Penalty for removing picket.

45. Any person found removing or disturbing, with intent to remove, any stake, picket or other mark placed under the provisions of this Act, shall forfeit and pay a sum not exceeding $20 and costs; and, in default of payment of the fine and costs, may be imprisoned for any period not exceeding one month. R.S.O. 1887, c. 31, s. 32.

Appointment of constables in mining divisions.

46. Every Inspector appointed in and for a mining division under this Act may appoint any number of constables not exceeding four; and the persons so from time to time appointed shall be, and they are hereby constituted, respectively constables and peace officers for the purposes of this Act, for and during the terms and within the mining divisions for which they are appointed respectively. R.S.O. 1887, c. 31, s. 33.

Act respecting riots near public works to be in force in mining divisions.

Rev. Stat. c. 34.

47.—(1) The Lieutenant-Governor in Council may, as often as occasion requires, declare by proclamation that he deems it necessary that *The Act respecting Riots near Public Works* shall, so far as the provisions therein are applicable, be in force within any mining division or divisions; and upon from and after the day to be named in any such proclamation section 1 and sections 3 to 11 inclusive of the said Act shall, so far as the provisions thereof can be applied therein, take effect within the mining division or mining divisions designated in the proclamation; and the provisions of the said Act shall apply to all persons employed in any mine, or in mining within the limits of such mining division or divisions, as fully and effectually to all intents and purposes as if the persons so employed had been specially mentioned and referred to in the said Act.

(2) The Lieutenant Governor in Council may in like manner from time to time declare the said Act to be no longer in force in such mining division or divisions; but this shall not prevent the Lieutenant-Governor in Council from again declaring the same to be in force in any such mining division or mining divisions, and no such proclamation shall have effect within the limits of any city. R.S.O. 1887, c. 31, s. 34.

Penalty for contravening this Act.

48. Every person contravening this Part of this Act or any rule or regulation made under it, in any case where no other penalty or punishment is imposed, shall, for every day on which such contravention occurs, or continues or is repeated, incur a fine of not more than $20 and costs; and, in default of payment of the fine and costs, he may be imprisoned for a term of not more than one month. R.S.O. 1887, c. 31, s. 36.

49. Every Inspector for a mining division may convict upon view of any of the offences punishable under the provisions of this Part of this Act or any regulations made under it. R.S.O. 1887, c. 31, s. 37.

Inspector may convict on view.

50. The contravention on any day of any of the provisions of this Part of this Act, or of any regulation made under it, shall constitute a separate offence and may be punished accordingly. R.S.O. 1887, c. 31, s. 38.

Separate offence.

51. Fees, penalties and fines received under this Act, and the costs of all such convictions as take place before any Inspector or Magistrate appointed under this Act, shall form part of the consolidated revenue fund of this Province, and be accounted for and otherwise dealt with accordingly; and the expenses of carrying this Act into effect in any mining division or mining divisions shall be paid by the Lieutenant-Governor out of the said consolidated revenue fund. R.S.O. 1887, c. 31, s. 39.

Application of fees, fines and penalties.

52. The Inspector of any mining division, or any two Justices of the Peace having jurisdiction in the locality, may try and summarily convict any person guilty of any offence under this Part of this Act, or of any breach of the provisions thereof, to which any fine or penalty or forfeiture of money is attached, and shall have all the powers of Justices of the Peace under *The Act respecting Summary Convictions before Justices of the Peace and Appeals to General Sessions*; but this section shall not be construed to give jurisdiction to try or summarily convict for any breach of the provisions of section 27 of this Act. R. S. O. 1887, c. 31, s. 40.

Mode of trial by Inspector or Justices.

PART IV—MINING REGULATIONS.

53. This Part shall not apply to any mine unless more than six persons other than the owner are employed under ground, nor to stone quarries; but nevertheless the owners or agents of such mines shall observe and keep the provisions of sections 54 and 55 of this Act, and in case of non observance thereof shall incur the penalties provided for by section 69 of this Act. 53 V. c. 10, s. 2.

Application of this Part.

EMPLOYMENT OF WOMEN AND CHILDREN

54 No boy under the age of fifteen years shall be employed in or allowed to be for the purpose of employment in any mine to which this Act applies below ground; and no girl or woman shall be employed at mining work or allowed to be for the purpose of employment at mining work in or about any mine. 53 V. c. 10, s. 4.

Employment of women and children.

Hours of employment of boys.

55. A boy or male young person of the age of fifteen and under the age of seventeen years shall not be employed in or allowed to be for the purpose of employment in any mine to which this Part applies below ground for more than forty-eight hours in any one week, or more than eight hours in any one day, or otherwise than in accordance with the regulations following, that is to say :

1. The period of such employment shall be deemed to begin at the time of leaving the surface, and to end at the time of returning to the surface.
2. A week shall mean the period between midnight on Sunday night and midnight on the succeeding Saturday night. 53 V. c. 10, s. 5.

Register to be kept of boys and male young persons employed.

56. The owner or agent of every mine to which this Part applies shall keep in the office at the mine, or in the principal office of the mine belonging to the same owner in the district in which the mine is situated, a register, and shall cause to be entered in such register the name, age, residence and date of the first employment of all boys or of all male young persons of the age of fifteen and under the age of seventeen years who are employed in the mine below ground, and shall produce such register to any Inspector at the mine at all reasonable times when required by him, and allow him to inspect and copy the same. The immediate employer of every boy or male young person of the age aforesaid, other than the owner or agent of the mine, before he causes such boy or male young person to be in any mine to which this Part applies below ground, shall report to the owner or agent of such mine, or some person appointed by such owner or agent, that he is about to employ him in such mine. 53 V. c. 10, s. 6.

Employment of young persons in connection with engines.

57. Where there is a shaft, inclined plane, or level in any mine to which this Part applies, whether for the purpose of an entrance to such mine or of a communication from one part to another part of such mine, and persons are taken up, down or along such shaft, plane or level by means of any engine, windlass or gin, driven or worked by steam or any mechanical power, or by an animal, or by manual labour, a person shall not be allowed to have charge of such engine, windlass or gin, or of any part of the machinery, ropes, chains or tackle connected therewith, unless he is a male of at least twenty years of age. Where the engine, windlass or gin is worked by an animal, the person under whose direction the driver of the animal acts shall for the purposes of this section be deemed to be the person in charge of the engine, windlass or gin, but such driver shall not be under sixteen years of age. 53 V. c. 10, s. 7.

Penalty for employment of persons contrary to Act.

58.—(1) If any person contravenes or fails to comply with any provision of this Act with respect to the employment of women, girls, young persons or boys, or to the register of or report respecting boys and male young persons, or to the employment of persons about any engine, windlass or gin, he shall be guilty of an offence against this Act, and in case of any such contravention, or non-compliance by any person whomsoever in the case of any mine, the owner and agent of such mine shall each be guilty of an offence against this Act, unless he proves that he had taken all reasonable means by publishing and to the best of his power enforcing the provisions of this Act to prevent such contravention or non-compliance.

(2) If it appears that a boy or young person or person employed about an engine, windlass or gin was employed on the representation of his parent or guardian that he was of that age at which his employment would not be in contravention of this Act, and under the belief in good faith that he was of that age, the owner or agent of the mine and the immediate employer shall be exempted from any penalty, and the parent or guardian shall for such misrepresentation be deemed guilty of an offence against this Act. 53 V. c. 10, s. 8.

PAYMENT OF WAGES.

Prohibition of payment of wages at public houses, etc.

59.—(1) No wages shall be paid to any person employed in or about any mine to which this Part applies at or within any public house, beer shop or place for the sale of any spirits, wine, beer or other spirituous or fermented liquor, or other house of entertainment, or any office, garden or place belonging or contiguous thereto or occupied therewith.

(2) Every person who contravenes, or fails, or permits any person to contravene or fail to comply with this section shall be guilty of an offence against this Act, and in the event of any such contravention or non-compliance in the case of any mine by any person whomsoever the owner and agent of such mine shall each be guilty of an offence against this Act, unless he proves that he had taken all reasonable means by publishing and to the best of his power enforcing the provisions of this section to prevent such contravention or non-compliance. 53 V. c. 10, s. 9.

ANNUAL REPORT OF STATISTICS.

Returns by owners and agents of mines.

60.—(1) The owner or agent of every mine to which this Part applies shall, on or before the first day of December in every year, send to the Bureau of Mines a correct return for the year ending on the preceding 31st day of October of the number of persons ordinarily employed in or about such mine below ground and above ground respectively, and distinguishing the different classes and ages of the persons so employed whose hours of labour are regulated by this Act, the average rate of wages of each class and the total amount of wages paid during the year, the quantity in statute weight of the mineral dressed and of the undressed mineral which has been sold, treated or used during that year, and the value or estimated value thereof.

(2) The return shall be in such form as may be from time to time prescribed by the Director of the Bureau, who shall furnish forms for the purpose of such return.

(3) Every owner or agent of a mine who fails to comply with this section or makes any return which is to his knowledge false in any particular, shall be guilty of an offence against this Act. 53 V. c. 10, s. 10.

Prevention of Accidents.

Notice of accidents in mines to be sent to Bureau of Mines.

61. Where in or about any mine to which this Act applies, whether above or below ground, either

1. Loss of life or any personal injury to any person employed in or about the mine occurs by reason of any explosion of gas, powder, or of any steam boiler; or
2. Loss of life or any serious personal injury to any person employed in or about the mine occurs by reason of any accident whatever, the owner or agent of the mine shall, within twenty-four hours next after the explosion or accident, send notice in writing of the explosion or accident and of the loss of life or personal injury occasioned thereby to the Director of the Bureau of Mines and shall specify in such notice the character of the explosion or accident and the number of persons killed and injured respectively.

Where any personal injury, of which notice is required to be sent under this section results in the death of the person injured, notice in writing of the death shall be sent to the Inspector within twenty-four hours after such death comes to the knowledge of the owner or agent. Every owner or agent who fails to act in compliance with this section shall be guilty of an offence against this Act. 53 V. c. 10, s. 11.

Notice of opening and abandonment of mine to be given.

62. In any of the following cases, namely:

1. Where any working is commenced for the purpose of opening a new shaft for any mine to which this Part applies;
2. Where a shaft of any mine to which this Part applies is abandoned, or the working thereof discontinued;
3. Where the working of a shaft of any mine to which this Part applies is recommenced after an abandonment or discontinuance for a period exceeding two months; or
4. Where any change occurs in the name of a mine, or in the name of the owner or agent of a mine to which this Part applies, or in the officers of any incorporated company which is the owner of a mine to which this Part applies;

The owner or agent of such mine shall give notice thereof to the Inspector within two months after such commencement, abandonment, discontinuance, recommencement or change, and if such notice is not given the owner or agent shall be guilty of an offence against this Act; provided that this section shall apply only to any working or mine in which more than twelve persons are ordinarily employed below ground 53 V. c. 10, s. 12.

Fencing of abandoned mine.

63.—(1) For the prevention of accidents, where any mine to which this Part applies is abandoned or the working thereof discontinued, at whatever time such abandonment or discontinuance occurred the owner thereof, and every other person interested in the minerals of the mine, shall cause the top of the shaft and any side entrance from the surface to be and to be kept securely fenced; or shall cause a sign-board to be strongly nailed to a post not less than eight feet high at the top of the shaft, and at any side entrance from the surface, on which there shall be painted in conspicuous letters in durable material the words "Abandoned Mining Shaft." Provided that—

Proviso.

1. Subject to any contract to the contrary, the owner of the mine shall, as between him and any other person interested in the minerals of the mine, be liable to carry into effect this section, and to pay any costs incurred by any other person interested in the minerals of the mine in carrying this section into effect.
2. Where such abandonment or discontinuance has occurred in the case of a mine before the 7th day of April, 1890, this section shall apply only to such shaft or side entrance of the mine as is situate within fifty yards of any highway, road, footpath or place of public resort, or in open or unenclosed land; or, not being situate as aforesaid, is required by an Inspector in writing to be fenced on the ground that it is specially dangerous.

(2) If any person fail to act in conformity with this section he shall be guilty of an offence against this Part, and any shaft or side entrance which is not fenced, or in respect of which the said signboard is not nailed up and kept nailed up as aforesaid as required by this section, and is within fifty yards of any highway, road, footpath or place of public resort, or is in open or unenclosed land, or is required by an Inspector as aforesaid to be fenced, shall be deemed to be a nuisance. 53 V. c. 10, s. 13.

POWERS AND DUTIES OF INSPECTOR.

Inspector not to be interested in mines.

64. No person shall be appointed or authorized to be qualified to act as an Inspector who practices or acts or is a partner of any person who practices or acts as a mining agent, or who is employed by the owners of or is interested in any mine. 53 V. c. 10, s. 14.

Powers of Inspector.

65.—(1) An Inspector under this Act shall have power to do all or any of the following things, namely:

1. To make such examination and enquiry as may be necessary to ascertain whether the provisions of this Part relating to matters above ground or below ground are complied with in the case of any mine to which this Part applies.
2. To enter, inspect and examine any mine to which this Part applies, and every portion thereof, at all reasonable times by day and night, but so as not to impede or obstruct the working of the said mine.
3. To examine into and make enquiry respecting the state and condition of any mine to which this Part applies, or any portion thereof, and the ventilation of the mine, and all matters and things connected with or relating to the safety of the persons employed in or about the mine, or any mine contiguous thereto, and to give notice to the owner or agent in writing of any particulars in which he considers such mine or any portion thereof or any matter, thing or practice to be dangerous or defective, and to require the same to be remedied within the period of time named in such notice, and unless the cause of danger be removed or such defect be remedied within the time named, the owner or agent shall be guilty of an offence against this Act. 53 V. c. 10, s. 15.
4. To exercise such other powers as may be necessary for carrying this Part into effect.

Penalty for obstructing Inspector.

(2) Every person who wilfully obstructs any Inspector in the execution of his duty under this Act, and every owner and agent of a mine who refuses or neglects to furnish to the Inspector the means necessary for making any entry, inspection, examination or enquiry under this Act in relation to such mine, shall be guilty of an offence against this Act. 53 V. c. 10, s. 15.

Plans to be produced on inspection of mine.

66. On the occasion of any examination or inspection of a mine the owner shall, if required so to do, produce to the Inspector or any other person duly authorized by the Commissioner of Crown Lands, an accurate plan of the workings thereof; every such plan as aforesaid shall show the workings of the mine up to within six months of the time of the inspection and the owner shall, if required by such Inspector or other authorized person, cause to be marked on such plan the progress of the workings of the mine up to the time of such inspection, and shall also permit the Inspector to take a copy or tracing thereof. 53 V. c. 10, s. 24.

67. Every Inspector under this Act shall make an annual report of his proceedings during the preceding year to the Director of the Bureau of Mines, which report shall be laid before the Legislative Assembly. The Commissioner of Crown Lands may at any time direct an Inspector to make a special report with respect to any accident in a mine to which this Act applies, which accident has caused loss of life or personal injury to any person, and in such case shall cause such report to be made public at such time and in such manner as he thinks expedient. 53 V. c. 10, s. 16.

Reports of Inspector.

68. In the event of a vacancy in the office of Mining Inspector any notice by this Act required to be given to such officer shall be given to the Director of the Bureau of Mines. 53 V. c. 10, s. 17.

Service of notices pending appointment of Inspector.

PENALTIES.

69. Every person employed in or about a mine other than an owner or agent who is guilty of any act or omission which in the case of an owner or agent would be an offence against this Part shall be deemed to be guilty of an offence against this Act, and shall be liable to a penalty not exceeding, if he is an owner or agent, fifty dollars, and if he is any other person ten dollars for each offence; and if an Inspector has given written notice of any such offence, to a further penalty not exceeding five dollars for every day after such notice that such offence continues to be committed. 53 V. c. 10, s. 18.

Penalties.

70. Any complaint or information made or laid in pursuance of this Act shall be made or laid within three months from the time when the matter of such complaint or information respectively arose, and

Limitation of prosecutions and form of information.

1. The description of any offence under this Act in the words of this Act shall be sufficient in law.
2. Any exception, exemption, proviso, excuse or qualification, whether it does or does not accompany the description of the offence in this Act, may be proved by the defendant but need not be specified or negatived in the information, and if so specified or negatived no proof in relation to the matter so specified or negatived shall be required on the part of the informant. 53 V. c. 10, s. 19.

71. No prosecution shall be instituted against the owner or agent of a mine to which this Part applies for any offence under this Act except by an Inspector, the county or district attorney, or with the consent in writing of the Attorney-General; and in the case of any offence of which the owner or agent of a mine is not guilty, if he proves that he had taken all reasonable means to prevent the commission thereof an In-

Prosecution for offences.

spector shall not institute any prosecution against such owner or agent if satisfied that he had taken such reasonable means as aforesaid. 53 V. c. 10, s. 20.

Prosecution under other Acts.

72—(1) Nothing in this Act shall prevent any person from being indicted or liable under any other Act or otherwise to any other or higher penalty or punishment than is provided for any offence by this Act, so that no person be punished twice for the same offence.

(2) If the court before whom a person is charged with an offence under this Act thinks that proceedings ought to be taken against such person for such offence under any other Act or otherwise, the Court may adjourn the case to enable such proceedings to be taken. 53 V. c. 10, s. 21.

Manner in which prosecutions may take place.

73. All prosecutions for the punishment of any offence under this Act may take place before any two or more of Her Majesty's Justices of the Peace having jurisdiction in the county or district in which the offence is committed, or before a Police or Stipendiary Magistrate, and the forms appended to an Act of the Parliament of Canada entitled *An Act Respecting Summary Proceedings before a Justice of the Peace*, or forms to the like effect or similar thereto, shall in all cases be sufficient. 53 V. c. 10, s. 22.

GENERAL RULES.

General rules

74. The following general rules shall, so far as may be reasonably practicable, be observed in every mine to which this Part applies.

Ventilation.

1. An adequate amount of ventilation shall be constantly produced in every mine to such an extent that the shafts, winzes, sumps, levels, underground stables and working places of such mine, and the travelling roads to and from such working places, shall be in a fit state for working and passing therein.

Gunpowder and blasting.

2. Gunpowder, dualine, dynamite or other explosive or inflammable substance shall only be used underground in the mine as follows:

a. It shall not be stored in the mine in any quantity exceeding what would be required for use during six working days.

b. It shall not be taken for use into the workings of the mine except in a securely covered case or canister, containing not more than eight pounds.

c. A workman shall not have in use at one time in any one place more than one of such cases or canisters.

d. In charging holes for blasting, saving in mines excepted from the operation of this section by the Commissioner of Crown Lands, an iron or steel pricker shall not be used, and a person shall not have in his possession in the mine underground any iron or steel pricker, and an iron or steel tamping rod or stemmer shall not be used for ramming either the wadding or the first part of the tamping or stemming on the powder.

e. A charge of powder which has missed fire shall not be unrammed.

f. A charge which has missed fire may be drawn by a copper pricker, but in no case shall any iron or steel tool be used for the purpose of drawing or drilling out such charge.

Man-holes in self-acting or engine planes.

3. Every underground plane on which persons travel which is self-acting, or worked by an engine, windlass or gin, shall be provided (if exceeding thirty yards in length) with some proper means of signalling between the stopping places and the ends of the plane, and shall be provided in every case at intervals of not more than twenty yards with sufficient man-holes for places of refuge.

Spaces in horse roads.

4. Every road on which persons travel underground where the produce of the mine in transit exceeds ten tons in any one hour over any part thereof, and where the load is drawn by a horse or other animal, shall be provided at intervals of not more than one hundred yards with sufficient spaces for places of refuge, each of which spaces shall be of sufficient length, and of at least three feet in width between the wagons running on the tramroad and the side of the road; and the Commissioner of Crown Lands may, if he see fit, require the Inspector to certify whether the produce of the mine in transit on the road aforesaid does or does not ordinarily exceed the weight as aforesaid.

Keeping spaces clear.

5. Every man-hole and space for a place of refuge shall be constantly kept clear, and no person shall place anything in a man-hole or such space so as to prevent access thereto.

Fencing of old shafts.

6. The top of every shaft which was opened before the commencement of the actual working for the time being of the mine and has not been used during such actual working shall, unless the Inspector otherwise permits, be securely fenced, and the top of every other shaft which for the time being is out of use, or used only as an air shaft, shall be securely fenced, or in either case due notice shall be given by nailing up a signboard as in this Act is hereinbefore provided, as the Inspector shall direct.

Fencing of entrances to shafts.

7. The top and all entrances between the top and bottom of every working or pumping shaft shall be properly fenced, but this shall not be taken to forbid the temporary removal of the fence for the purpose of repairs or other operations, if proper precautions are used.

Securing of shafts.

8. Where the natural strata are not safe, every working or pumping shaft, adit, tunnel, drive, roadway or other workings shall be securely cased, lined or timbered, or otherwise made secure.

Safety from water.

9. Every mine shall be provided with proper and sufficient machinery and appliances for keeping such mine free from water, the accumulation or flowing of which might injuriously affect any other mine.

Division of shaft.

10. Where one portion of a shaft is used for the ascent and descent of persons by ladders or a man engine, and another portion of the same shaft is used for raising the material gotten in the mine, the first mentioned portion shall be cased or otherwise securely fenced off from the last mentioned portion.

Signalling.

11. Every working shaft in which persons are raised shall, if exceeding fifty yards in depth, and not exempted in writing by the Inspector, be provided with guides and some proper means of communicating distinct and definite signals from the bottom of the shaft and from every entrance for the time being in work between the surface and the bottom of the shaft to the surface, and from the surface to the bottom of the shaft and to every entrance for the time being in work between the surface and the bottom of the shaft.

Cover overhead.

12. A sufficient cover overhead shall be used when lowering or raising persons in every working shaft, except where it is worked by a windlass, or where the person is employed about the pump or some work of repair in the shaft, or where a written exemption is given by the Inspector.

Chains.

13. A single linked chain shall not be used for lowering or raising persons in any working shaft or plane except for the short coupling chain attached to the cage or load.

Slipping of rope on drum.

14. There shall be on the drum of every machine used for lowering or raising persons such flanges or horns, and also, if the drum is conical, such other appliances as may be sufficient to prevent the rope from slipping.

Brake.

15. There shall be attached to every machine worked by steam, water or other mechanical power, and used for lowering or raising persons, an adequate brake, and also a proper indicator (in addition to any mark on the rope) which shows to the person who works the machine the position of the cage or load in the shaft.

Inclination of ladders.

16. A proper footway or ladder, inclined at the most convenient angle which the space in which the ladder is fixed allows, shall be provided in every working shaft where no machinery is used for raising or lowering persons; and every such ladder shall have substantial platforms at intervals of not more than forty feet, and no such ladder shall be fixed for permanent use in a vertical or overhanging position unless in shafts used exclusively for pumping. In every mine in which vertical or overhanging ladders shall be in use in the shaft at the time

when these rules shall be applied to it, they may be retained provided securely fixed platforms be constructed at intervals of not more than 30 feet from each other, and such ladders have sufficient spaces for footholds of not less than six inches.

Dressing room.

17. If more than twelve persons are ordinarily employed in the mine below ground, sufficient accommodation shall be provided above ground near the principal entrance of the mine, and not in the engine house or boiler house, for enabling the persons employed in the mine to conveniently dry and change their clothes.

Fencing machinery.

18. Every fly-wheel and all exposed and dangerous parts of the machinery used in or about the mine shall be and be kept securely fenced.

Gauges to boilers and safety-valves.

19. Every steam boiler shall be provided with a proper steam gauge and water gauge, to show respectively the pressure of steam and the height of water in the boiler, and with a proper safety valve.

Wilful damage.

20. No person shall wilfully damage, or without proper authority remove or render useless, any fencing, casing, lining, guide, means of signalling, signal, cover, chain, flange, horn, brake, indicator, ladder, platform, steam-gauge, water-gauge, safety-valve or other appliance or thing provided in any mine in compliance with this Act.

Contravention of rules to be an offence.

21. Every person who contravenes or does not comply with any of the general rules in this section shall be guilty of an offence against this Act, and in the event of any contravention of or non-compliance with any of the said general rules in the case of any mine to which this Act applies by any person whomsoever being proved, the owner and agent of such mine shall each be guilty of an offence against this Act unless he proves that he had taken all reasonable means by publishing and to the best of his power enforcing the said rules as regulations for the working of the mine to prevent such contravention or non-compliance. 53 V. c. 10, s. 23.

Punishment for defacing notices.

75. Every person who pulls down, injures or defaces any rules, notice or abstract posted up by the owner or agent shall be guilty of an offence against this Act. 53 V. c. 10, s. 25.

Repealed Statutes.

76. Chapter 31 of the Revised Statutes of Ontario, 1887, chapters 9 and 10 of the Statutes of 53 Victoria, and chapter 8 of the Statutes of 54 Victoria are hereby repealed except in so far as may be necessary for the completion of transactions begun thereunder.

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